

There is No Such Thing as a Technological Accident

Cheap Natures, Climate Crisis & Technological Impasse

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Like Nature, *Technology* is one of our most dangerous words. It's a metaphysic, a narrative prime mover endowed with supernatural powers.

Such words are never innocent. They are never *just words*. They are guiding threads for the rulers, and, for the rest of us, everyday folk concepts. They shape what we see and what we don't see, what we prioritize, and what we ignore. These concepts do not merely describe the world; they license and guide modern ways of organizing power and re/production. They have real force in the world, because of what they mystify, and because of what they enable. Such ideas present themselves as innocent. They are anything but.

These ideas are *ruling abstractions*.² They are dangerous for two reasons. First, they appear in our imaginaries as agentless forces of history: they are brain erasers for world-historical memory. They *seem* to have "lives of their own" – which they emphatically do not.³ For over a century, it's been a temptation for the political left no less than for centrist and "eco-modernizing" techno-fixers. This is the "idea of mechanical progress, not merely as a necessary development but as an end in itself, *almost as a kind of religion*."⁴ The danger extends beyond false consciousness. Ruling abstractions are material forces, not just ideas but *belief structures*.⁵ They are developed, used, and periodically reinvented by the imperial bourgeoisie and their intelligentsias to practically reshape the world in ways favorable to the endless accumulation of capital. Ruling abstractions are the building blocks of hegemonic ideologies that trickle down to the folk concepts of everyday life. From the Levellers to Blockadia, radical movements have challenged these abstractions. But they also must live with the contradictions – as Orwell underlines. When Lenin moved from the furious denunciation to critical acceptance of Taylorism and Fordism after 1917, he was doing what all revolutionaries must do: wrestle with the contradictions of

¹ Forthcoming, *Technological Accidents*, Joke Brower and Sjoerd van Tuinen, eds. (Leiden: V2 Publishing), 2023.

² Jason W. Moore, "The Opiates of the Environmentalists?" *Abstrakt*, November, 2021, (<https://www.polenekoloji.org/>); idem, "Power, Profit and Prometheanism, Part I: Method, Ideology and the Violence of the Civilizing Project," *Journal of World-Systems Research*, vol. 21, no. 2, 2022, 415-424.

³ Barbara Jeanne Fields, "Slavery, race and ideology in the United States of America," *New Left Review*, first series, 181, 1990, 95-118.

⁴ George Orwell, *The Road to Wigan Pier* (London: Victor Gollancz Limited, 1937), 220-1, emphasis added.

⁵ Jason W. Moore, "How to Read Capitalism in the Web of Life," *Journal of World-Systems Research*, vol. 21, no. 1, 2022, 153-168.

capitalism.⁶ Those contradictions are far more than mechanical.⁷ They are ideological, social, ecological, cultural... and planetary.

Sometimes demon, sometimes savior, the ruling abstraction Technology conjures something mystical, outside of history yet relevant to it. Its power is the alchemist's illusion: the magical notion that machinery will produce something out of nothing. Our uppercase emphasizes the double register of both Nature and Technology: as ruling abstractions, central to modern mythmaking, and as material processes of power, profit and life. Disentangling and resynthesizing the two moments – the ideological and the material – is difficult.

The difficulty stems from ideological mystification, not intrinsic complexity. I am not asking the reader to design a Mars rocket. The superficially counter-intuitive character of my argument shows how bourgeois ideology paints radical critique as unduly complex and unrealistic. Nowhere is this more evident than in its ruling abstractions, like Nature and Technology. Capitalism – through the media, the schools, and the professions – has so thoroughly indoctrinated us into the procedures of Cartesian thought, with its fantasy of thinking substances and extended substances, that it takes a deliberate and sustained choice to think dialectically.⁸ Either/or thinking is so hegemonic that our neural pathways often resist the dialectical imagination's emphasis on unity-in-difference. This makes it challenging to grasp historical movements as “rich totalities of many determinations.”⁹ The alternative asks us not only to interrogate the ruling abstractions that sneakily find their way underneath our critical sensibilities and set up shop in our preconceptual habitus; it asks us to see how those ruling abstractions operate in world history, becoming – as a young Marx once quipped – ideas with “material force.”¹⁰

Nature and Technology, the ruling ideas, are so central to modern thought and everyday language that questioning them might sound absurd. Their common sense, descriptive innocence is so obvious that anyone who points out their ideological character must be insane – or some Ivory Tower thinker who prefers word games over hard-headed analysis. But these ideas are conceptual hammers of imperial rule and its false promise of Progress. As abstractions, they have material consequences. To liken the web of life to a machine, or the biosphere to a spaceship, is not merely an intellectual problem but a political and ideological one.¹¹ The responsibility of radical critique in the climate crisis is to lay bare the interpenetrating relations of class power, ideology and the forces of production in the web of life. How one *thinks* about Technology –

⁶ Raj Patel and Jason W. Moore, *A History of the World in Seven Cheap Things* (Berkeley: University of California Press, 2017).

⁷ The best introduction to Marx's thinking on the relations of life, class, and productive forces is Paul Burkett, *Marx and Nature: A Red and Green Perspective* (New York: St. Martin's Press, 1999).

⁸ R.C. Lewontin, S. Rose & L.J. Kamin, *Not in Our Genes* (New York: Pantheon, 1984).

⁹ Karl Marx, *Grundrisse* (New York: Vintage, 1973), 99.

¹⁰ Karl Marx, *Critique of Hegel's 'Philosophy of Right'* (Cambridge: Cambridge University Press, 1970 [1843]), 137.

¹¹ Steven Shapin, *The Scientific Revolution* (Chicago: University of Chicago Press, 1996); R. Buckminster Fuller, *Operating Manual for Spaceship Earth* (Carbondale: Southern Illinois University Press, 1969); Jason W. Moore, “Waste in the Limits to Capital: How Capitalism Lays Waste to the Web of Life, and Why It Can't Stop,” *Emancipations*, 2023, in press.

and therefore Nature – is fundamental to one’s world-historical conception of the crisis and its origins, and therefore essential to one’s political assessments, “environmental” and otherwise.

The dominant intellectual and ideological view – “critical” or not – fragments the world into discrete concept boxes: Nature, Society, Economy, Technology, Race, whatever. The fragmented worldview – deeply indebted to the Cartesian primacy of parts over wholes – leads to interpretations of the climate crisis through causal pluralism, systems theory, and generalized schemes of interactivity rather than dialectical interpenetration and totality. In such approaches, parts trump the whole – or the whole overwhelms the parts. (Two sides of the same epistemological coin.) The result is an intellectual and ideological impasse that fails to do what any effectively radical critique of the climate crisis must: identify the emerging “weak links” in the chains of imperial power and class exploitation in the unfolding planetary crisis.¹²

The dialectical – and I would say world-ecological – alternative begins neither with parts nor wholes, but guiding threads. Let us take the example of the technology/resource nexus most closely identified with the climate crisis. On the left these days, the notion of “fossil capital” is hegemonic.¹³ It powerfully implicates the class relations of steam power and coal from the early nineteenth century; it identifies the epochal character of varied permutations of oil, gas, and combustion engines since then. There is much to recommend in the thesis, but only to a point. It runs dangerously close to technological determinism and resource fetishism. As we’ll see, the history of the steam engine is wrapped up with a broader ensemble of technological, ideological, and imperial transformations. It was a crucial node in nineteenth-century industrialization, but was it decisive? Was it even the era’s most epochal machine?

These questions must be posed if we are to develop a revolutionary strategy for climate justice. Narrowing the problem to specific technological/resource combinations is not only historically problematic. A politics that flows from such reductionism is intrinsically vulnerable to ruling class “fixes” that reshuffle capitalism’s energetic-technological mix while preserving violent and unequal relations of class exploitation.¹⁴

Here we can remember the New Left slogan: the issue is not the issue.¹⁵ Blow up a pipeline and you may slow global warming for days or weeks. Transcend the thinking – and its enabling webs of power and profit – responsible for the pipelines, and another biosphere is possible. To be sure, thinking is not enough; it is necessary but insufficient for revolutionary synthesis. Without an intellectual “state shift” that moves beyond substance fetishes, methodological

¹² Jason W. Moore, “Metabolic Rift or Metabolic Shift?” *Theory & Society*, vol. 46, no. 4, 2017, 285-318; idem., “Anthropocene, Capitalocene & the Flight from World History,” *Nordia*, vol. 51, no. 2, 2022, 123-146.

¹³ Andreas Malm, *Fossil Capital* (London: Verso, 2016).

¹⁴ Such “fixes” should not be confused for either fundamental solutions or meaningful repair, see David Harvey, *The Limits to Capital* (Chicago: University of Chicago Press, 1982); Jason W. Moore and Raj Patel, “Reparatur und Fix unterscheiden: Zu einer Ökologie des Wiederaufbaus.” In *The Great Repair*, eds. Anh-Linh Ngo, et al. (Berlin: ARCH+ Verlag, 2022), 16-30.

¹⁵ Jason W. Moore, “Beyond Climate Justice.” In *The Way Out of...*, eds. Ekaterina Degot and David Riff (Berlin: Hatje Cantz Verlag, 2022), 105-130.

nationalism, and Cartesian thinking, popular movements for fundamental democratization will remain vulnerable: easily divided, repressed, and coopted by the identitarian and eco-reductionist temptations of progressive neoliberalism.¹⁶ A *connective* alternative is called for, one that understands how all socio-ecological forces and dynamics are *not* created equal but rather concretely – and hierarchically – structured by five centuries of the imperial bourgeoisie’s triumph in the global class war.¹⁷ Any vision for planetary justice and emancipatory technology (with an emphatically lowercase ‘t’) will need to prioritize the development of international, feminist, and multi-racial working-class movements that can politically secure – and defend – popular hegemony over investment decisions, and ensure the liquidation of private power over the fate of the planet and its creatures.

NATURAL DISASTERS, TECHNOLOGICAL ACCIDENTS & OTHER EXCUSES

An environmental justice slogan gained popularity after 2005’s Hurricane Katrina and the devastation of New Orleans and the Gulf Coast: *There is no such thing as a natural disaster*.¹⁸ To this we may add: *There is no such thing as a technological accident*. Unpredictable events are of course part of life. No one thinks that scientific and technical discovery occurs without accidents and unforeseen developments. If our concern is, however, with the potentially catastrophic relations between modern technology, power and webs of life – let us say since the “long” sixteenth century – a different interpretation is necessary.

Here we can build upon Paul Virilio’s perceptive and prescient amplification of Marx on the social relations of technology and its “accidents.”¹⁹ Every historical form of “technological” development is a social relation that invariably produces specific forms of risk and potential catastrophe. These unfold through the nexus of machinery, both “hard” (machinery) and “soft” (e.g., software, cartography). I would add that every epoch-making technology in the modern world is irreducibly socio-ecological – as cause and consequence.²⁰

For Virilio, *accident* and *technology* are quite different from our everyday language. I cannot here reprise Virilio’s lifetime of work on the matter. Making sense of capitalist technology asks us, Virilio implies, to wrestle with the history of epochal possibility, danger, and destruction. The arc of capitalism is to activate the danger of “integral accidents.” These “incorporat[e] a whole host of incidents and disasters in a chain reaction.”²¹ The climate crisis is just such an integral accident. It is no more the unpredictable outcome of capitalism than

¹⁶ Nancy Fraser, *The Old is Dying and the New Cannot Be Born* (London: Verso, 2019); Patel and Moore, *Seven Cheap Things*.

¹⁷ Jason W. Moore, “Our Capitalogenic World: Climate Crises, Class Politics and the Civilizing Project,” *Studia Poetica*, 2023, in press.

¹⁸ Chester W. Hartman and Gregory D. Squires, eds., *There is No Such Thing as a Natural Disaster: Race, Class, and Hurricane Katrina* (New York: Routledge, 2006).

¹⁹ The best point of departure is Paul Virilio, *The Paul Virilio Reader*, ed. Steve Redhead (Edinburgh: Edinburgh University Press, 2004).

²⁰ Jason W. Moore, *Capitalism in the Web of Life* (London: Verso, 2015).

²¹ Virilio, “The Museum of Accidents,” in *The Paul Virilio Reader*, 257.

Chernobyl or Hiroshima were the unexpected results of nuclear fission. To paraphrase Engels (and Spinoza), every determination generates its own negation.²²

Does it also include *our* negation? This is what “existential threat” and other expressions of climate doom suggest. I am not convinced. And yes, I have read “*the science*.”

Such climate doomism is essentially the product of three ideological dynamics. All are intimately linked to capitalism’s technological fetishism. One is the Cartesian worldview. If your cosmology is Man against Nature, the *political* resolution of the climate crisis as a geohistorical event is unthinkable; climate fixes manifest as technocratic and technological, fused through some version of Rationality and Progress. Such arguments – like Development in an earlier era and Sustainability today – are “anti-political” infrastructures of policy and global power.²³

Secondly, climate doomism is tightly connected to the imperial bourgeoisie’s repressed unconscious about *its* impending doom, about which we will learn more presently. Late monopoly capitalism has entered its Zombie phase: dead, but moving. And very deadly.²⁴ As capitalism sinks deeper into a productivist stagnation, its militarized edge cuts ever more sharply. For half a century, we’ve been promised a new scientific-technological revolution that would liberate humanity and the planet from poverty and ecocide. We are still waiting, and there are few grounds for optimism.

Third, climate doomism – which is different from acknowledging the extraordinary character of climate change at the end of the Holocene – ideologically excludes capitalism’s non-linear dynamics. Even in the absence of a climate crisis, capitalism volatility would be on the rise; the acceleration of capitalogenic climate change is not only *adding* a new “environmental” problem to a long-run set of contradictions; it’s amplifying those antagonisms, like inter-imperialist war and financial volatility.²⁵

From the steam engine to networked computing, technological change has constantly stimulated future-gazing imaginations, dystopian and utopian. As if to move from the frying pan into the fire, utopian technologies for some have been dystopian for others – nuclear power is a dramatic case in point. This is hardly a novel observation. For Marx, the development of the productive forces ushered in a utopia for the rich – and a hellish dystopia of overwork, exhaustion and death for the working classes.²⁶

²² Frederick Engels, *Anti-Dübring: Herr Eugen Dübring’s Revolution in Science* [1894]. In *Collected Works*, Vol. 25: *Engels*, Karl Marx and Frederick Engels, 5-312 (New York: International Publishers, 1987), 131.

²³ Moore, “The Opiates of the Environmentalists?”

²⁴ Jason W. Moore, 2022e. “Global Capitalism in the Great Implosion,” in *Can Global Capitalism Endure?*, William I. Robinson, ix-xxiv (Atlanta: Clarity Press, 2022); idem., “Del Gran Abaratamiento a la Gran Implosión,” *Relaciones Internacionales*, vol. 47, 2021, 11-52

²⁵ Jason W. Moore, “Cheap Food & Bad Climate: From Surplus Value to Negative Value in the Capitalist World-Ecology,” *Critical Historical Studies*, vol. 2, no. 1, 2015, 1-42; idem., “Imperialistische Kriege in der Endphase der billigen Natur: Klima, Weltkrieg und Revolution,” *Das Argument*, 2023, in press.

²⁶ Karl Marx, *Capital*, Vol. I (New York: Vintage, 1977).

Capitalism's extraordinary expansion of the social surplus, instead of freeing humanity from misery and poverty, was an instrument of repression, domination, and endless exploitation from the outset. The "advancing" productive forces combined surplus value and surplus repression, psychic no less than bodily. Notably, that surplus repression has always been more than psychological and physical: the accumulation of misery.²⁷

It is equally tied to capitalism's sacrifice zone strategy, a dynamic of militarized accumulation and Prometheism, of the domination of humans and the rest of life to render the "conquest of nature" profitable.²⁸ Technology for Marx is therefore mechanical, but always more than mechanical. It congeals power, profit and life into forms compatible with the compulsion to accumulate without cease. (Moses and the Prophets!) Its absurdity grows daily, apace with its capacity to lay waste to humans and the rest of planetary life.²⁹

CHEAP NATURES, OR, THE TECHNOLOGICAL LOGIC OF HISTORICAL CAPITALISM

What if Virilio's compelling rendering of integral accidents – as "chain reactions" of "incidents and disasters" – is turned inside out, into the heart of capitalism's much-vaunted capacity for "innovation"? Integral accidents issue from capitalism's specific integration of power, profit and life. This cannot be reduced to the narrowly economic; modern technologies are so destructive because they incorporate capitalism's *political* constitution of the conditions of profitability: hence the centrality of imperialism and states in capitalist environment-making. Unless we accept the fetish of Technology as a metaphysic of historical change, we must look at the specific relations that dominate the life of a civilization and its punishment/reward nexus for technological change. From this perspective, we may grasp capitalism's ongoing technological stagnation in the climate crisis. Technological *stagnation* refers not to some abstract benchmark of Progress, but to the specificity of capitalism's technological regime: the imperative to realize rising relative surplus value (labor productivity) necessary to counteract its tendency towards *economic* stagnation.³⁰

Among the great geohistorical insights of twentieth-century social thought is a simple thesis: capitalism destroys its capacity for technological innovation not because of its failures, but from its success.³¹ The claim that technological progress has slowed considerably will surely elicit skepticism from readers.³² Bear with me.

²⁷ Marx, *Capital*; Fathun Karib Satrio, *Living in the Ruins of the Capitalocene*, PhD dissertation, Department of Sociology, Binghamton University, 2022.

²⁸ John Peter Antonacci, "Periodizing the Capitalocene as Polemocene," *Journal of World-Systems Research*, vol. 27, no. 2, 2021, 439-467.

²⁹ Moore, "Waste in the Limits to Capital."

³⁰ Paul A. Baran and Paul M. Sweezy, *Monopoly Capitalism* (New York: Monthly Review Press, 1966).

³¹ Joseph Schumpeter, *Capitalism, Socialism, and Democracy* (London: George Allen & Unwin, 1954), 61ff; Giovanni Arrighi, *The Long Twentieth Century* (London: Verso, 1994).

³² Jason E. Smith, *Smart machines and service work: automation in an age of stagnation* (New York: Reaktion Books, 2020); David Graeber, "Of flying cars and the declining rate of profit," *The*

From the standpoint of capital, one issue dominates: Does a given technology facilitate or undermine the endless accumulation of capital? The terms of that question are complex, but not unfathomably so. To clarify, we are not dealing with “better mousetraps” but the history of “epoch-making technologies.”³³ These have been relatively few and far between in the history of capitalism. Everyone has a different list, but early capitalism’s shipping-shipbuilding-cartography revolutions, successive military revolutions, the steam engine/cotton gin nexus, and the internal combustion engine are reasonably include.³⁴

Whether or not the information/computing complex represents a new “industrial revolution” has been debated since the 1970s. I don’t think it is revolutionary, for a specific reason: it has failed to launch a significant advance in labor productivity growth and the conditions for a new “material” expansion of capitalism.³⁵ This is hardly a controversial statement. As early as 1987, Robert Solow quipped that “the computer age everywhere but in the productivity statistics.”³⁶ Notwithstanding a modest uptick after 1996, the trend has been persistently downwards since the early 1970s. That’s when futurologists – all pro-capitalist – started promising us robot factors in a “superindustrial revolution.”³⁷ Instead ICT has facilitated the global sweatshop and America’s permanent war regime.

Modern technologies become epoch-making to the degree that they join with new imperial and managerial movements to expand and appropriate frontiers of Cheap Nature. Here is a decisive limit to capitalism in the web of life: the exhaustion of frontiers, opened at gunpoint after 1492, were by the 1970s increasingly exhausted. Today, those frontiers – terrestrial, aquatic, and atmospheric – are gone.³⁸ This is the source of capitalism’s Zombie phase.

Technologies are epoch-making for two connected reasons. First, they open new opportunities for reviving, sustaining and advancing the rate of profit for capital *as a whole* – the enlarged surplus value accruing overwhelmingly to capitalists in the imperial centers. This is the economic moment. Secondly, they allow for the appropriation of geological and biological work – resources, crops, forest resources – in cheap, and geologically or biologically significant ways. Fossil fuels are a paradigm instance. This is the geophysical moment. The two join dialectically to resolve – or aggravate – the surplus capital problem.

Baffler vol. 19, 2012, 66-84; Gopal Balakrishnan, “Speculations on the Stationary State,” *New Left Review*, series 2, no. 59, 2009, 5-26; Aaron Benanav, “Automation and the Future of Work – I,” *New Left Review*, series 2, no. 119, 2019, 5-38; idem, “Automation and the Future of Work – II,” *New Left Review*, series 2, no. 120, 2019, 117-146.

³³ Baran and Sweezy, *Monopoly Capitalism*, 218.

³⁴ Jason W. Moore, “The Capitalocene, Part I,” *Journal of Peasant Studies*, vol. 44, no. 3, 2017, 594-630; idem, “The Capitalocene, Part II,” *Journal of Peasant Studies*, vol. 45, no. 2, 237-279.

³⁵ Robert J. Gordon, *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War* (Princeton: Princeton University Press, 2016).

³⁶ Robert Solow, “We’d Better Watch Out,” *New York Times Book Review*, 12 July, 1987, 36.

³⁷ Zbigniew Brzezinski, *Between Two Ages: America’s Role in the Technetronic Era* (New York: Viking, 1971); Alvin Toffler, *Future Shock* (New York: Bantam, 1970).

³⁸ Moore, *Capitalism in the Web of Life*.

Capital's dynamism is so great that it generates world surplus value above and beyond what can be reinvested profitably. Billionaires can only spend so much on hundred-million-dollar yachts and mansions. At the end of the day, they must find *profitable* investment opportunities – sufficient to *expand* an always-rising mass of accumulated capital. But suppose they do not find sufficiently profitable opportunities in the “productive” sphere. Then, the One Percent tends to sink its capital into unproductive sectors, favoring rentierism and militarism: real estate, finance, and war machines.³⁹

Historically, such militarism – taking the form of successive “new” imperialisms in each great wave of capitalist development – worked because it opened new frontiers of Cheap Nature.⁴⁰ This was not merely about the redistribution of surplus value through imperialist rents; it was fundamentally, about the quantitative and qualitative expansion of the ecological surplus: the ratio of unpaid work/energy to the mass of capital. All manner of investments suddenly become profitable when the ecological surplus is high -- when raw materials and labor are suddenly cheaper and more abundant. Thus every great industrialization – from the long sixteenth century to the postwar golden age – called forth an imperialism that restored and expanded the supplies of the Four Cheaps: labor and unpaid work, food, energy, and raw materials. This is far more important to the history of capitalist technology than usually supposed. Successive “military revolutions” have been hothouses of proletarianization, financial innovation, and technological development.⁴¹ Advances in gun manufacture, for instance, were critical nodes in the “first” nineteenth century's industrialization (c. 1780s-1850s), first in Britain and then in the “American system.”⁴² Global capitalism's cybernetics-computing infrastructure since the 1940s was, for decades, incubated in the American military-industrial complex.⁴³

Technological “fixes” to the surplus capital problem – in Harvey's sense of the term – are never purely, or even primarily, technical. They materialize through the nexus of mechanization in the imperial centers and the political possibilities of appropriating unpaid work/energy on the frontiers.⁴⁴ Capitalism's epoch-making technologies have depended on, and often developed

³⁹ Jason W. Moore, “World Accumulation and Planetary Life, or, Why Capitalism Will Not Survive Until the ‘Last Tree is Cut’,” *IPPR Progressive Review*, vol. 24, no. 3, 2017, 176-204; Arrighi, *The Long Twentieth Century*.

⁴⁰ Jason W. Moore, “Ecology, Capital, and the Nature of Our Times: Accumulation and Crisis in the Capitalist World-Ecology,” *Journal of World-Systems Research*, vol. 17, no. 1, 2011, 108-147

⁴¹ Lewis Mumford, *Technics and Civilization* (New York: Harcourt, Brace and Company, 1934); Patel and Moore, *Seven Cheap Things*.

⁴² Priya Satia, *Empire of Guns: The Violent Making of the Industrial Revolution* (Penguin, New York: Penguin, 2018); David Hounshell, *From the American System to Mass Production, 1800-1932: The Development of Manufacturing Technology in the United States*. (Baltimore, MD: The Johns Hopkins University Press, 1984).

⁴³ Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia University Press, 1993); Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: The MIT Press, 1996).

⁴⁴ Harvey, *Limits to Capital*; Moore, *Capitalism in the Web of Life*.

through, frontiers of Cheap Nature. Without these, epoch-making capitalist technologies don't happen.

THE MACHINERY OF CHEAP NATURE: INDUSTRIALIZATION FROM KING COTTON TO THE WASHINGTON CONSENSUS

Consider the steam engine. It was developed at the pithead of coal mines to drain water in the early eighteenth century. The frontier in question was *subterranean*: vertical rather than horizontal. Cheap Energy was so abundant at the coal mines that the steam engine's inefficiency was economically tolerable. Decades of experimentation followed, underwritten by Cheap Energy. While Watts' rotary steam engine after 1784 saw gradual diffusion, the real breakthrough in British industry did not occur until after 1830.

Why the lag? Part of the answer is found across the Atlantic. The British textile industry consumed cotton, and cotton supplies were limited – and relatively expensive. *Cheap* cotton – which meant *abundant* cotton – was necessary for “the” Industrial Revolution. Marx knew it at the time: “Only the large fall in the price of cotton... enabled the cotton industry to develop in the way that it did.”⁴⁵ Cheap cotton's technological pivot was the cotton gin. The gin has a very long history, but its modern breakthrough is typically dated from Eli Whitney's breakthrough in 1793-94. The new gin enabled a prodigious advance in labor productivity in physical terms. Early adopting regions like South Carolina saw a 1266 percent increase in cotton exports per slave in the 1790s.⁴⁶ While slave prices rose modestly, cotton export prices plummeted, but the cotton gin's extraordinary labor productivity advances offset those falling prices to make cotton cultivation a lucrative enterprise. (Itself made possible by a new slave regime organized through gang labor management.)

This was no technological accident. The cotton gin's epoch-making character was closely linked to the consolidation of the American republic; its capacity to expel indigenous peoples and move to frontiers of fertile soil; flows of capital from West Indian sugar plantations; and of course the British empire and its deindustrialization of India. Cotton and textile output surged on both sides of the Atlantic. If there was a “key machine” of British-led industrialization, it was the cotton gin, not the steam engine.⁴⁷

Around 1830, the steam engine became dominant in British textile manufacturing. But its world-historical centrality was not in industry but trade and empire. The steam engine's epoch-making character is therefore only partly a story of advancing labor productivity (of “relative surplus value”) – as Anglo-centric Marxists maintain.⁴⁸ The steam engine was not only an industrial but a

⁴⁵ Karl Marx, *Theories of Surplus Value*, Volume III (Progress Publishers, Moscow, 1971), 368.

⁴⁶ Peter C. Mancall, Joshua L. Rosenbloom, and Thomas Weiss, “Agricultural Labor Productivity in the Lower South, 1720–1800,” *Explorations in Economic History*, vol. 39, no. 4, 2002, 390-424.

⁴⁷ The phrase is Mumford's (*Technics and Civilization*), commenting on the *sixteenth-century* industrial revolution and the centrality of the mechanical clock, see Patel and Moore, *Seven Cheap Things*.

⁴⁸ Malm, *Fossil Capital*.

war machine, deployed to open new frontiers of Cheap Nature. Steam-powered gunships would be seen from the opium wars to the scramble for Africa.

Railroads were just as significant. Completing the first North American transcontinental in 1869 enabled U.S. military power to destroy indigenous resistance. Globally, it's no accident that the railroad revolution more or less follows (and thence enabled) the British hegemonic ascent after 1815.⁴⁹

The nineteenth-century's railroad boom (c. 1850-1914) contributed mightily to fixing the surplus capital problem.⁵⁰ Along with the steamship and gunboat, railroads facilitated imperialism's unprecedented global reach, realizing the enclosure of planetary life for the first time. This allowed for the planet-wide appropriation of unpaid work/energy, setting the stage for the "second" industrialization (c. 1873-1914) and the long postwar boom. New flows of Cheap grain, tin, copper, oil, rubber, nickel and other strategic inputs directly subsidized the rise of the automobile, electrical, and petrochemical industries. Thus the steam-engine/railroad complex allowed for not only massive flows of surplus capital to find a profitable outlet. The railroads, carrying soldiers, settlers and colonial administrators, allowed the militarized projection of capitalist power into regions previously untouched by capital: frontiers of Cheap Nature.⁵¹

The rise of American capitalism, for instance, turned on the annihilation of space by time, materialized through those continent-devouring ribbons of steel, appropriating the soil, water, forests, and metals of North America into feedstock for monopoly capitalism.⁵² But the process was hardly limited to North America. Through railroadization – and later, automobilization – vast ecological surpluses could be won from the minimally capitalized extraction of mineral resources, cereal cultivation, and so forth on the new frontiers.¹⁸ This allowed capitalists to appropriate the Four Cheaps. As the second industrial revolution gained traction in the 1870s, it could do so with abundant supplies of Cheap Nature, thereby avoiding the spectre of underproduction faced by earlier waves of industrialization.

What happens to technological change and world accumulation once the closure – and thence implosion – of frontiers begins? As we've seen, capitalist dynamism creates economic crises because it accumulates capital faster than it generates new outlets for investment. The chief counter-tendency derives from opening frontiers that deliver labor, food, energy and raw materials at well-below the prevailing cost. This explains why great technological revolutions occur as input prices fall – including labor costs. In brief, restoring the

⁴⁹ Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940* (Oxford: Oxford University Press, 1988).

⁵⁰ David Harvey, *The Urbanization of Capital: Studies in the History and Theory of Capitalist Urbanization* (Baltimore, MD: The Johns Hopkins University Press, 1985); Baran and Sweezy, *Monopoly Capital*.

⁵¹ Geoffrey Barraclough, *An Introduction to Contemporary History* (New York: Penguin, 1967); Jason W. Moore, "Transcending the Metabolic Rift: A Theory of Crises in the Capitalist World-Ecology," *The Journal of Peasant Studies*, vol. 38, no. 1, 2011, 1-46.

⁵² Jason W. Moore, "Remaking Work, Remaking Space: Spaces of Production and Accumulation in the Reconstruction of American Capitalism, 1865-1920," *Antipode*, vol. 34, no. 2, 2002, 176-204.

Four Cheaps increases profitability, encouraging investment and technical change. But this requires new, cheaply and consistently delivered natures.⁵³

The Great Frontier fixes overaccumulation crises because successive industrial revolutions and their “operational landscapes” rely on one or another strategic primary commodity: Dutch *fluitschips* were assembled with cheap timber from Norway; Manchester textile factories with cheap cotton from the American South; Henry Ford’s Model T’s were profitable to manufacture only because of cheap oil.⁵⁴ For every Amsterdam, there is a Norway; for every Manchester, there is a Mississippi.

Those commodities are Cheap in a specific economic sense. (This is not to abstract the *geocultural* relations of cheapening and its superexploitative character, which ideologically enable downward price movements.) Not only must they have a strategic, *qualitative* role in technological revolution (e.g. coal, oil, bauxite). They must also meet two further requirements: 1) their supply must rise significantly; 2) their value composition must fall significantly. Without rising labor productivity – in some concert of physical and price measures – Cheapness cannot be realized. In addition to its narrowly technical dimensions, the matter is also decisive because it raises questions about the strategic character of class struggle in primary sectors. To the degree that capital wins those class struggles (often but not always through technical change), labor productivity advances and unit costs fall. In these conditions, average labor-time in primary commodity output declines, allowing falling prices. Primary commodity prices fell 1.2 percent annually from 1900 until 2003, when the latest commodity “supercycle” began.⁵⁵ Although temporarily stalled around 2013, by the end of the decade a new phase of this long commodity boom commenced: a “climate supercycle.”⁵⁶

The first significant signs of an epochal crisis of Cheap Nature – and the withering of the historical relation between technological change and productivity revolution – appeared in the long 1970s. I cannot reprise that history here. It’s enough to note that the long postwar “golden age” ended with the 1972-75 commodity boom.⁵⁷ That commodity boom was characterized by sharply rising food, energy, and metals prices. By 1974, the capitalist world-ecology was in the grips of the most severe economic downturn since the Great Depression. There were of course multiple contradictions in play.

⁵³ Richard Walker and Jason W. Moore, “Nature, Value, and the Capitalist Vortex,” in *Interrupting the Anthropo-ob(S)cene: Political Possibilities in the Natures of Cities*, E. Swyngedouw & H. Ernston, eds., 48-68 (New York: Routledge, 2018).

⁵⁴ For the history of Cheap Nature and industrializations, see Moore, *Capitalism in the Web of Life*; Patel and Moore, *Seven Cheap Things*. On operational landscapes, see Neil Brenner, *New Urban Spaces* (Oxford: Oxford University Press, 2019); Nikos Katsikis, *From Hinterland to Hinterlobe: Urbanization as Geographical Organization*, Doctor of Design (DDes) thesis, Graduate School of Design (GSD), Harvard University, 2016; Neil Brenner, and Nikos Katsikis, “Operational landscapes: Hinterlands of the Capitalocene,” *Architectural Design*, vol. 90, no. 1, 2020, 22-31.

⁵⁵ Jeremy Grantham, “Time to Wake Up: Days of Abundant Resources and Falling Prices Are Over Forever,” *The GMO Quarterly Letter*, April, 2011.

⁵⁶ Nicholas Beuret, “The Climate Supercycle,” *The Ecologist*, 14 May, 2021.

⁵⁷ Richard N. Cooper, Robert Z. Lawrence, Barry Bosworth, and Hendrik S. Houthakker, “The 1972-75 Commodity Boom,” *Brookings Papers on Economic Activity* no. 3, 1975, 671-723.

Among them was the growing assertiveness of Third World nationalism. It was dramatized by OPEC's struggle to capture oil profits from transnational firms headquartered in the imperialist countries – but also through the efforts of “semi-peripheral” developmentalist states, like Mexico and Brazil, to pursue nationalist industrialization strategies.⁵⁸ To make a long story short, the crisis of the 1970s was resolved through Washington's capacity to subordinate both the petro-states and Third World developmentalism to a new model that—through the debt regime, death squads, and “economic hit men” – allow for a renewal of Cheap Nature.⁵⁹

It worked. Sort of. After 1982, the neoliberal “boom” was enabled by a significant cyclical decline in food, energy, and resource prices. Commodity prices for food declined 39 percent – and metals by half – between 1975 and 1989. By 1983, oil stabilized, for the next twenty years, at a price per barrel about twice that of the postwar average.⁶⁰

This global fix was realized by enclosing the last meaningful frontiers of Cheap Nature. These were, however, smaller than ever. Meanwhile, the piles of surplus capital were greater than ever. Yes, there was the North Sea petro-bonanza. But this was no Ghawar field. There were “new agricultural countries.”⁶¹ But these were small fry compared to opening Australia and North America to capitalist agriculture in the long nineteenth century. The ecological surplus contracted and profitability faltered. Accumulation was reflat only through neoliberal “structural adjustment,” backstopped by US-sponsored Third World fascism.⁶² In other words, the new Cheap Natures were obtained through new regimes of austerity and authoritarianism, linked directly to financialization by any means necessary. As technical possibility in the productive sphere contracted, an increasingly predatory capitalism emerged that sought to win through redistribution what it could no longer appropriate on the frontiers.⁶³

Technologically speaking, this model prioritized a global sweatshop regime over the anticipated robot factories promised in the 1970s. As I've argued elsewhere, this regime was essentially a “Robin Hood in reverse” model of systemwide wage repression. Wage cuts for the proletariat and the dispossession of peasantries substituted for a labor-technological revolution. This obviated two historical problems for capital. One of them was identified by Marx: the rising capitalized composition of production (crudely, more expensive machines) tends towards a falling rate of profit. This had been in motion across

⁵⁸ Roberto J. Ortiz, *The Political Ecology of Global Oil: Uneven Development, Petrodollar Illusions and Climate Crisis, 1900-2019*, PhD dissertation (Department of Sociology, Binghamton University, 2019).

⁵⁹ John Perkins, *Confessions of an Economic Hit Man* (New York: Berrett-Koehler, 2005).

⁶⁰ Moore, *Capitalism in the Web of Life*, 236-237.

⁶¹ Harriet Friedmann, “Distance and Durability: Shaky Foundations of the World Food Economy,” *Third World Quarterly*, vol. 13, no. 2, 1992, 371-383.

⁶² Noam Chomsky and Edward S. Herman, *The Washington Connection and Third World Fascism* (Boston: South End Press, 1979); Naomi Klein, *The Shock Doctrine: The Rise of Disaster Capitalism* (New York: Macmillan, 2007).

⁶³ Saskia Sassen, *Expulsions: Brutality and Complexity in the Global Economy* (Cambridge, MA: Harvard University Press, 2014); David Harvey, *The New Imperialism* (Oxford: Oxford University Press, 2003).

the imperialist centers since the 1870s.⁶⁴ But it had been cyclically counteracted by the frontier movement towards cheaper raw materials: a cheapening of Marx's "circulating capital" could check the tendency towards rising machinery costs.⁶⁵ The other problem was the proletarian struggle. Highly industrialized, capitalized production systems generated new, increasingly militant working classes, as the postwar experience of Western Europe, Brazil, South Korea, and South Africa demonstrated.⁶⁶ Wage repression was, understandably from the perspective of capital, entangled with other repressive movements. This impinges directly on the neoliberal technological regime, whose innovations are centered on developing the machinery of global surveillance and militarization over a labor productivity revolution. These are technologies of the shock doctrine, the security services, and American regime change wars.⁶⁷

Hence the distinctiveness of the neoliberal era, foreshadowing its Zombie phase since 2008. The neoliberal era did not generate a "third technological revolution" along the lines of previous industrializations (c. 1800-1830, 1880-1910).⁶⁸ Technical development has undoubtedly occurred. But it "failed to release a productivity revolution that would reduce costs and free up income for an all-round expansion."⁶⁹

TECHNOLOGY, CLIMATE CRISIS & THE GREAT IMPLOSION: 'INTEGRAL ACCIDENTS' OVER THE LONGUE DUREE

This post-2008 technological impasse – a Great Stagnation – manifests not only in industry but also in agriculture, whose subordination in the long sixteenth century made the rise of capitalism possible. Every capitalist industrialization has depended upon an agricultural revolution that has produced more and more food with less and less labor-power. Thanks to the climate crisis, class struggles, and manifold biophysical antagonisms swirling around the pesticide-herbicide regime, capitalism's agro-technological dynamism has come to an end.⁷⁰ This is the Great Stagnation.

The twenty-first-century demise of Cheap Nature won't be linear. There are no soft landings for civilizations in the thick of climate crisis. We are living through the relative calm of the Great Stagnation. It signals capitalism's planetary crisis. Technology will not save the day. It's hardwired to appropriate Cheap Natures, not resolve interconnected "state shifts" in the web of life that

⁶⁴ Esteban Ezequiel Maito, "The Tendency of the Rate of Profit to Fall since the Nineteenth Century and a World Rate of Profit," in Guiglielmo Carchedi and Michael Roberts, eds., *World in Crisis: A Global Analysis of Marx's Law of Profitability*, 129-156 (Chicago: Haymarket, 2018).

⁶⁵ Karl Marx, *Capital*, vol. III (New York: International Publishers, 1968), 111-119.

⁶⁶ Gay W. Seidman, *Manufacturing Militance: Workers' Movements in Brazil and South Africa, 1970-1985* (Berkeley: University of California Press, 1994); Beverly J. Silver, *Forces of Labor: Workers' Movements and Globalization since 1870* (Cambridge: Cambridge University Press, 2003).

⁶⁷ Klein, *The Shock Doctrine*.

⁶⁸ Ernest Mandel, *Late Capitalism* (London: New Left Books, 1975), 121ff.

⁶⁹ Balakrishnan, "Speculations on the Stationary State," 14.

⁷⁰ Jason W. Moore, "The End of the Road? Agricultural Revolutions in the Capitalist World-Ecology, 1450-2010," *The Journal of Agrarian Change*, vol. 10, no. 3, 389-413; idem, "Cheap Food and Bad Climate: From Surplus Value to Negative-Value in the Capitalist World-Ecology," *Critical Historical Studies*, vol. 2, no. 1, 1-42.

result *from* those appropriations. To paraphrase Einstein, the technological regime that creates these interconnected crises – Virilio’s integral accident on an epochal scale – cannot resolve them.

The planetary crisis is typically reduced to a biophysical danger misleadingly characterized as an “existential threat to humanity.”⁷¹ Climate catastrophism is a species of political rhetoric long mobilized by the political right – not movements for democracy and socialism.⁷² In the present conjuncture, catastrophism and doomism manifest as the repressed unconscious of the imperial bourgeoisie, whose historical conditions of reproduction are exhausted. This does *not* rule out a “decadent” transition through which ruling classes reinvent themselves and the mode of production – something that occurred after the crisis of feudalism.⁷³ (Which was also climate-related.)

Capitalism’s contemporary crisis reveals its epochal character through two developments. One is the unfolding crisis in life-making; the other, an emerging crisis in profit-making, registered in the discourse on “secular stagnation.”⁷⁴ Both are intimately connected to historical capitalism’s technological dynamism, and to its epochal technological impasse in the climate crisis.

Climate and technical change are intimately linked in the history of capitalism. Ours is not the first capitalogenic climate crisis. Between the 1550s and the early 1700s, a “long cold seventeenth century” of climate change, economic crisis, and political volatility descended upon the northern hemisphere.⁷⁵ It was amplified by the slaving-induced genocides that killed 95 percent of the New World’s indigenous population. Among its consequences was a modest (but significant) atmospheric decarbonization.⁷⁶ This contributed to significant cooling. The long, cold seventeenth century was the hardest stretch of the Little Ice Age (c. 1300-1850), which was in turn the coldest period of the past 8,000 years.⁷⁷

Technical change in this long, cold seventeenth century was so rapid that we might call it the *first* modern industrialization, enabled by the new productivist

⁷¹ Associated Press, “Fossil fuel dependence poses ‘direct existential threat’, warns UN chief,” *The Guardian*, 11 September, 2018.

⁷² Sasha, Lilley, David McNally, Eddie Yuen and James Davis. *Catastrophism: The Apocalyptic Politics of Collapse and Rebirth* (Oakland, PM Press, 2012).

⁷³ Samir Amin, “Revolution or Decadence? Thoughts on the Transition between Modes of Production, on the Occasion of the Marx Bicentennial,” *Monthly Review*, vol. 70, no. 1, 17-23; Immanuel Wallerstein, *Historical Capitalism* (London: Verso, 1983).

⁷⁴ Lawrence H. Summers, “The age of secular stagnation: What it is and what to do about it,” *Foreign Affairs*, vol. 95, no. 2, 2016, 2-9; John Bellamy Foster and Michael D. Yates, “Piketty and the crisis of neoclassical economics,” *Monthly Review*, vol. 66, no. 6, 2014, 1-24.

⁷⁵ Emmanuel Le Roy Ladurie and Valerie Daux, “The Climate in Burgundy and Elsewhere, from the Fourteenth to the Twentieth Century.” *Interdisciplinary Science Reviews* vol. 33, 2008, 10-24; Geoffrey Parker, *Global Crisis: War, Climate Change, and Catastrophe in the Seventeenth Century* (New Haven, CT: Yale University Press, 2013).

⁷⁶ Catherine M. Cameron, Paul Kelton, and Alan C. Swedlund, eds. *Beyond Germs: Native Depopulation in North America* (Tucson: University of Arizona Press, 2015); Simon L. Lewis and Mark A. Maslin, “Defining the Anthropocene.” *Nature*, vol. 519, no. 7542, 2015, 171-80.

⁷⁷ Heinz Wanner, Christian Pfister, and Raphael Neukom, “The Variable European Little Ice Age.” *Quaternary Science Reviews*, 287, 2022, 107531

empires across the Americas.⁷⁸ As empires of Cheap Nature wrapped their tentacles around life and labor from Brazil to the Baltic, new technical possibilities materialized. Innovations in shipbuilding, milling, mining and smelting, agriculture in Europe and on the sugar frontiers, and countless other sectors culminated in Newcomen's atmospheric steam engine, introduced in 1712. These were technical and productivist moments of an audacious "climate fix." Leading European empires enclosed and exploited the unpaid work/energy of the Atlantic in an epoch-making turn.⁷⁹ Its technological dynamism flowed from Cheap Nature: a geocultural and geopolitical regime of devaluation and wage repression. On this basis emerged the capitalogenic trinity of the climate class divide, climate patriarchy, climate apartheid.⁸⁰ These are the sources, not the consequences, of the planetary inferno.

It also inaugurated the Great Frontier.⁸¹ Its windfall profits – realized through new sources of Cheap food, labor, energy, and raw materials – fueled technological revolutions for the next four centuries. Those revolutions were made possible by the Great Cheapening. This was a long-run secular decline in the price (value composition) of the Big Four inputs: labor-power, food, energy, and raw materials. A specifically capitalist historical nature was born: *Cheap Nature*. Its epoch-making service to world accumulation enabled the long-run reduction of re/production costs for capital. It epochal technologies were those that would either capitalize upon the Cheap Natures flowing into capital's vortex, or enable the forcible extension of the Cheap Nature regime to the whole of planetary life.

We are now witnessing that strategy's implosion. The web of life is rapidly moving from a source of Cheapness to an unavoidable vector of rising costs. *Extra-human* labor – the *biotariat*, if you will – is in open revolt.⁸² This is the

⁷⁸ John U. Nef, *Conquest of the Material World* (Chicago: University of Chicago Press, 1964); Immanuel Wallerstein, *The Modern World-System I* (New York: Academic Press, 1974).

⁷⁹ Jason W. Moore, "Nature and the Transition from Feudalism to Capitalism," *Review: A Journal of the Fernand Braudel Center*, vol. 26, no. 2, 2003, 97-172; idem, "The Modern World-System as Environmental History? Ecology and the Rise of Capitalism," *Theory & Society*, vol. 32, no. 3, 2003, 307-377; idem, *Ecology and the rise of capitalism*, PhD dissertation (Department of Geography, University of California, Berkeley, 2007); idem, "Madeira, Sugar and the Conquest Of Nature in the 'First 'Sixteenth Century, Part I: From 'Island Of Timber ' to Sugar Revolution, 1420-1506." *Review: A Journal of the Fernand Braudel Center*, vol. 35, no. 4, 2009, 345-90; idem, "'Amsterdam is standing on Norway,' Part I: The alchemy of capital, empire, and nature in the diaspora of silver, 1545-1648," *The Journal of Agrarian Change*, vol. 10, no. 1, 2010, 33-68; idem, "'Amsterdam is standing on Norway,' Part II: The global North Atlantic in the ecological revolution of the long seventeenth century," *The Journal of Agrarian Change*, vol. 10, no. 2, 2010, 188-227; idem, "Madeira, Sugar and the Conquest Of Nature in the 'First 'Sixteenth Century, Part II: From Local Crisis to Commodity Frontier, 1506-1530." *Review: A Journal of the Fernand Braudel Center* vol. 33, no. 1, 2010, 1-24; idem, "'This Lofty Mountain of Silver could Conquer the Whole World': Potosí in the World-Ecological Revolution of the Long Seventeenth Century," *Journal of Philosophical Economics*, vol. 4, no. 1, 2010, 58-103.

⁸⁰ Jason W. Moore, "The Capitalocene and Planetary Justice," *Maizę* no. 6, 2019, 49-54; idem, "Empire, Class and The Origins Of Planetary Crisis: The Transition Debate in the Web of Life." *Esboços* 28, 2021, 740-763.

⁸¹ Walter Prescott Webb, *The Great Frontier* (Austin: University of Texas Press, 1964).

⁸² Stephen Collis, "Notes Towards a Manifesto of the Biotariat," *Beating the Bounds*, July, 2014, <https://beatingthebounds.com/2014/07/25/notes-towards-a-manifesto-of-the-biotariat/>;

Great Implosion. The unfolding Great Stagnation, does not mean there are zero frontiers of Cheap Nature. There *are* frontiers (e.g. Amazonia). But these are tiny compared to the surplus capital problem. Without Cheap Natures to underwrite rising profitability, there will be no reversal of the ongoing collapse of investment, and no new scientific-technological revolution – at least, not in the ways capitalism has known it since 1492.

THE GREAT STAGNATION OF PROFIT AND PRODUCTIVITY: PRELUDE TO THE GREAT IMPLOSION

The Great Stagnation is the exhaustion of Cheap Nature and therefore the exhaustion of the specifically capitalist technological regime. The signs are everywhere. Three dominate, turning on overaccumulated capital and faltering labor productivity. They portend dramatic contractions. First is the secular decline of profitability. The world rate of profit has been falling since the 1870s – temporarily counter-acted at various junctures, especially between 1947 and 1966, and again, modestly, between 1983 and 2003.⁸³ The mass of accumulated capital continues to grow without a corresponding expansion of profitable investment opportunities.⁸⁴ As these stagnate, rentier tendencies advance.⁸⁵ Capitalists gravitate towards “political accumulation.”⁸⁶ They grow increasingly reliant on state power to secure its reproduction – and away from productive investment. More and more, they “look for unproductive investments like property to replace investment in production when profitability in productive assets falls.”⁸⁷ One indicator is found in 2019 reports identifying 17 *trillion* dollars in government bonds with “below-zero yields.” Meanwhile, capitalist real estate investment has spiked. Such investment is not productive investment, but “property owned for the express purpose of achieving investment returns.” That grew 50 percent between 2013 and 2019, reaching \$9.8 trillion.⁸⁸ American financial corporations, whose rising share of corporate profits defined Euro-American neoliberal capitalism, saw that share decline sharply after

Jason W. Moore, “[El hombre, la naturaleza y el ambientalismo de los ricos](#),” in *Pensar la Ciencia de Otro Modo*, eds. F.F. Herrera, D. Lew, and Nerliny Caruci, 55-82 (Caracas: Mincyt, 2022).

⁸³ Michael Roberts, *The Long Depression* (Chicago: Haymarket, 2016), esp. 9-30; Maito, “The Tendency of the Rate of Profit to Fall since the Nineteenth Century.

⁸⁴ There is an important debate between the rising mass of accumulate capital and the declining rate of profit, see David Harvey, “Rate and Mass,” *New Left Review*, second series, 130, 2021, 73-98; Michael Roberts, “The Rate and the Mass of Profit,” *The Next Recession*, 25 August, 2021, <https://thenextrecession.wordpress.com/2021/08/25/the-rate-and-the-mass-of-profit/>. So far as we discussing the possibilities for a new epochal technological revolution, I give the edge to Roberts. In my view, the rising mass of capital, to the degree that it finds a very low rate of profit, will gravitate towards a reproduction strategy that is increasingly militarized.

⁸⁵ Brett Christophers, *Rentier Capitalism: Who Owns the Economy, and Who Pays for It?* (London: Verso, 2020).

⁸⁶ Dylan Riley and Robert Brenner, “Seven Theses on American Politics,” *New Left Review*, second series, 138, 2022, 5-27.

⁸⁷ Roberts, *The Long Depression*, 226.

⁸⁸ Kyle Campbell, “Growth of the \$9trn Global Real Estate Market in Six Charts,” *PERE News* (27 July, 2020).

2002 and then stagnate.⁸⁹ Nonfinancial investment in the USA – and across the global core – collapsed in the early 2000s and has yet to recover.⁹⁰ China’s aggressive Keynesianism during the Great Recession (c. 2008-10) “rescued” global capitalism. That counter-tendency was shortlived.⁹¹ It should not be overemphasized. In China too, labor costs have been rising and the organic composition of capital with it. After a temporary rise during the Great Recession, profitability has fallen and remains well below 2008 levels.⁹² This explains some measure of China’s savvy resource acquisition strategy (One Belt, One Road). Without vast frontiers of Cheap Nature, China cannot lead capitalism into a new golden age.

The Great Implosion’s next two indicators turn on technological stagnation. Here our focus is the “real basis” of capital accumulation: labor productivity. We can distinguish two principal forms of labor productivity, in agriculture and the so-called “secondary” and “tertiary” sectors. We may consider these in their respective turns.

In the heartlands of capitalist agriculture, productivity growth has slowed dramatically since the Eighties. In American agriculture, labor productivity growth over the past four decades has declined by more than a third relative to the postwar average (1948-1980/1981-2014); in the European Union, agricultural labor productivity growth struggled to reach one percent annually in the 2010s.⁹³ American yield growth in such critical commodity crops as maize and wheat fell sharply in the 2000s against the postwar average. Relative to 1936-90, American corn yield growth fell by 39 percent and wheat, 70 percent.⁹⁴ For Indian wheat, at the center of the Green Revolution, yield growth

⁸⁹ Rune Skarstein, “Overaccumulation of Productive Capital or of Finance Capital? A View from the Outskirts of a Marxist Debate,” *Investigación Económica*, vol. 70, 2011, 51-87; Jacob Assa, “Great Moderation or Financialization of Volatility?” Paper presented to the conference, *10 Years After The Crash: What Have We Learned?*, Berlin (2018), https://www.researchgate.net/publication/328318741_Great_Moderation_or_Financialization_of_Volatility_An_Integrated_Macroeconomic_Approach.

⁹⁰ Rex Nutting, “Shareholder primacy is ruining America,” *MarketWatch* (22 May, 2019), <https://www.marketwatch.com/story/capitalism-is-failing-america-says-a-conservative-republican-2019-05-20>; Michael Roberts, “The Debt Dilemma,” *The Next Recession*, 10 May, 2020, <https://thenextrecession.wordpress.com/2020/05/10/the-debt-dilemma/>; idem, *The Long Depression*, esp. 235-272.

⁹¹ David Harvey, “Abstract from the Concrete: Capitalism Spiralling out of Control,” in Alberta Andreotti, David Benassi, and Yuri Kazepov, eds., 45-60, *Western Capitalism in Transition* (Manchester: Manchester University Press, 2018).

⁹² Editors, “Measuring the Profitability of Chinese Industry,” *Chuāng* (21 June, 2020), <https://chuangcn.org/2020/06/measuring-profitability/>

⁹³ K.O. Fuglie, et al., “Productivity Growth in U.S. Agriculture,” *Economic Brief* 9 (Washington, D.C.: US Department of Agriculture, 2007), 5; for the EU, see European Commission, “Agricultural labour productivity on the rise again,” Eurostat 16 December (2021), <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20191216-1>.

⁹⁴ Calculated from Matthew A. Andersen, et al., “A Century of US farm Productivity Growth: A Surge then a Slowdown,” *American Journal of Agricultural Economics*, vol. 100, no. 4, 2018, 1072-1090, quotation: 1085.

collapsed in the same period, tumbling from 3.4 percent annually in the 1980s to just 0.6 percent in the 1990s.⁹⁵

Climate change explains a critical increment of this agricultural slump. Notwithstanding breathless talk of a biotechnology revolution in agriculture, there's been no reversal of this productivity stagnation for decades.⁹⁶ Nor is "climate-smart" agriculture – the latest in capitalist techno-babble – achieved anything.⁹⁷

The fact is that capitalist agriculture is becoming more – not less "climate sensitive."⁹⁸ That's a reasonably anodyne description with epochal implications. Recall capitalism's simple agricultural model: produce more and more food with less and less labor-power. If that logic –an expansionary and not steady-state model – breaks down, all bets are off. For now, the best that can be said of world agriculture is that it's treading water. But the climate crisis portends an epochal reversal, from slow to negative growth.⁹⁹ A sobering 2017 report sees climate change pushing agricultural productivity back to "pre-1980 levels by 2050 even when accounting for present rates of innovation."¹⁰⁰

The climate's suppression of agriculture productivity isn't speculative. By 2008, global maize and wheat output was 3.8 percent and 5.5 percent lower than it would have been in a world without climate change.¹⁰¹ By 2021, Ortiz-Bobea and her colleagues found capitalogenic climate change responsible for a "loss of the past seven years of productivity growth." Suppose there was no climate change: the productivity gains realized in 2020 would have been achieved in 2013.¹⁰² Like everything about climate change, the global mean obscures considerable unevenness. While climate change has suppressed world productivity growth by 20 percent since 1961, that figure was 30 percent greater for the Caribbean and a whopping 70 percent higher for sub-Saharan Africa.¹⁰³

⁹⁵ I. Matuschke and M. Qaim, "Adoption and Impact of Hybrid Wheat in India," Paper presented to the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12–18, 2006, 2.

⁹⁶ Moore, "End of the Road?"

⁹⁷ Marcus Taylor, "Climate-Smart Agriculture: What is it Good for?," *The Journal of Peasant Studies*, vol. 45, no. 1, 2018, 89-107.

⁹⁸ Ariel Ortiz-Bobea, Erwin Knippenberg, and Robert G. Chambers, "Growing Climatic Sensitivity of US Agriculture Linked to Technological Change and Regional Specialization," *Science Advances*, vol. 4, no. 12, 2018, eaat4343.

⁹⁹ On agricultural revolutions and the Cheap Food model, from the origins of capitalism to the climate crisis, see Jason W. Moore, *Cheap Food & Bad Money: Food, Frontiers, and Financialization in the Rise and Demise of Neoliberalism*, *Review: A Journal of the Fernand Braudel Center*, vol. 33, nos. 2-3, 2012, 225-261; idem, "Environmental Crises and the Metabolic Rift in World-Historical Perspective," *Organization & Environment*, vol. 13, no. 2, 2000, 123-158; idem, "Cheap Food and Bad Climate."

¹⁰⁰ Xin-Zhong Liang, et al., "Determining Climate Effects on US Total Agricultural Productivity," *Proceedings of the National Academy of Sciences*, vol. 114, no. 12, 2017, E2285-E2292.

¹⁰¹ D.B. Lobell, et al., "Climate Trends and Global Crop Production since 1980," *Science*, vol. 333, no. 6042, 2011, 616-620.

¹⁰² Ariel Ortiz-Bobea, et al., "Anthropogenic Climate Change has Slowed Global Agricultural Productivity Growth," *Nature Climate Change* vol. 11, no. 4, 2021, 306-312, quotation: 309.

¹⁰³ Ortiz-Bobea, et al., "Anthropogenic Climate Change," 310.

If climate change is suppressing the Biotariat’s productivity, so too the Proletariat’s. A 2019 investigation by the International Labour Office found that rising heat stress “is a serious problem for a large proportion of the world’s 1 billion agricultural workers.”¹⁰⁴ As heat stress intensifies, by 2030, 2.2 percent of “total working hours worldwide will be lost, either because it is too hot to work or because workers have to work at a slower pace.” Those losses will increase in a non-linear way, as heat stress and other moments of climate change intensify. In South Asia and West Africa, productivity losses will more than double the global average.¹⁰⁵ By the 2030, world agriculture will bear one-third of global climate change costs. By 2060, two-thirds.¹⁰⁶

Finally, since the early 1970s, labor productivity growth in manufacturing and services has also slowed dramatically. In the U.S., labor productivity surged between 1920 and 1970, advancing 2.84 percent annually. Between 1970 and 2014, that rate was cut by more than a third, to 1.62 percent.¹⁰⁷ It hasn’t revived, and it probably won’t. In American manufacturing, real output per hour “was lower in 2017 than at its peak in 2010.” For France and Germany, the decline is even steeper. German productivity growth tumbled from 6.3 percent in the 1950s and 1960s to just 2.4 percent after 2000.¹⁰⁸ Service sector productivity growth is still weaker – and in most of the Global South, probably negative.¹⁰⁹ Even China’s spectacular labor productivity growth – some 7.2 percent a year between the 1993 and 2013 – did not offset the systemic tendency.¹¹⁰ Labor productivity in the Global North is still four times greater, and China’s productivity advances have been counter-acted by rising unit labor costs – 85 percent between 2000 and 2011.¹¹¹

The paradox is that “productivity growth rates in manufacturing collapsed precisely when they were supposed to be rising rapidly due to industrial automation.”¹¹² Arguably the greatest *non-event* of the neoliberal era is the non-appearance of a new “industrial revolution” premised on automation and its promise of significant productivity advances.¹¹³

¹⁰⁴ International Labour Office, *Working on a Warmer Planet: The Impact of Heat Stress on Labour Productivity and Decent Work*, Geneva: International Labour Office, 2019, 3. A brilliant account of agricultural labor, heat stress, and the devastation of workers’ health is on offer in Alex Nading, “The Heat of Work: Dissipation, Solidarity, and Kidney Disease in Nicaragua,” in Sarah Besky and Alex Blanchette, eds., *How Nature Works: Rethinking Labor on a Troubled Planet* (Santa Fe, NM: University of New Mexico Press, 2019), 97-114.

¹⁰⁵ ILO, *Working on a Warmer Planet*, 3, 13; also Kerstin K. Zander, et al., “Heat stress causes substantial labour productivity loss in Australia,” *Nature Climate Change*, vol. 5, no. 7, 2015, 647-651

¹⁰⁶ H. Braconier, et al., “Policy Challenges for the Next 50 Years,” *OECD Economic Policy Paper*, no. 9 (Paris: Organization for Economic Cooperation and Development, 2014).

¹⁰⁷ Gordon, *The rise and fall of American growth*.

¹⁰⁸ Benanav, “Automation and the Future of Work – I,” 19.

¹⁰⁹ Benanav, “Automation and the Future of Work – II,” 128.

¹¹⁰ International Labour Office, *Global Employment Trends 2014: Risk of a Jobless Recovery?* (Geneva: International Labour Office, 2014), 52.

¹¹¹ Midnight Notes Collective, *Promissory Notes: From Crisis to Commons* (Jamaica Plains, NY: Midnight Notes, 2010), 4.

¹¹² Benanav, “Automation and the Future of Work – I,” 19.

¹¹³ Moore, *Capitalism in the Web of Life*.

In the Seventies, social critics as diverse in their politics as Alvin Toffler and Ernest Mandel breathlessly anticipated an automated world.¹¹⁴ But it did not come. That non-appearance has everything to do with the enclosure of the Great Frontier and the corresponding exhaustion of Cheap Nature. Why? Because frontier appropriations geographically condition capitalism's epoch-making technological revolutions. While appearing to be a prodigious technological advance, ICT hasn't revived labor productivity growth. Nor have other "high-tech" and "green" technologies.¹¹⁵

TECHNOLOGY, CAPITALISM, AND THE ALCHEMIST'S ILLUSION

The non-linear Cheapening and devaluation of life and labor that enabled capitalism's survival in the seventeenth century is today activating its non-linear negation. This is *negative-value*: relations that initially become resistant, then intractable, in the face of capitalism's business-as-usual.¹¹⁶ (These include its technological fixes.) Whereas "limits to growth" thinking privileges substances, dialectical critique emphasizes relations that enfold substances, which in turn materially condition the relations.¹¹⁷ The faces of negative-value are manifold – they encompass everything from superweeds to the proliferation of "justice" movements (food, climate, energy, etc.) to climate change. These cannot be "fixed" in the ways established during the long, cold seventeenth century. The more the Great Frontier closes, the greater the desperation and force of the climate class divide, climate apartheid, and climate patriarchy. The Great Stagnation is also a Great Involution – capital's contradictions turn inwards on itself, yielding an unprecedented onslaught of toxification and violence. Why this should be so is straightforward: capitalism's business as usual, its ensemble of technical innovation, militarized accumulation, and Cheap Nature flowed through the Great Frontier. Frontiers enabled imperial bourgeoisies to check the tendency towards rising production costs, and to contain the dangerous classes set in motion by industrialization and imperialist superexploitation. Its closure represents a quantity-quality tipping point: an *epochal* crisis of capitalism.

Now we've come full circle. The epochal crisis was entirely foreseeable. There is no such thing as a technological accident. "Technological" disasters, accidents, and revolutions are always entwined within power, profit and life. They are social – and therefore *socio-ecological* – relations. In the history of

¹¹⁴ Toffler, *Future Shock*; Mandel, *Late Capitalism*, 184-222.

¹¹⁵ On the antagonism between "clean technology" and neoliberal rent-seeking, see Jesse L. Goldstein's *Planetary Improvement* (Cambridge, MA: MIT Press, 2018).

¹¹⁶ Moore, *Capitalism in the Web of Life*, 274-289; Gerardo Otero and Pablo Lapegna, "Transgenic crops in Latin America: Expropriation, Negative Value and the State," *The Journal of Agrarian Change*, vol. 16, no. 4, 2016, 665-674; James Graham, "A country with land but no habitat: Women, Violent Accumulation and Negative-Value in Yvonne Vera's *The Stone Virgins*," *Journal of Postcolonial Writing*, vol. 53, no. 3, 2017, 355-366; Treasa De Loughry, "Polymeric Chains and Petrolic Imaginaries: World Literature, Plastic, and Negative Value," *Green Letters*, vol. 23, no. 2, 2019, 179-193.

¹¹⁷ Donella H. Meadows, Dennis L. Meadows, Joergen Randers, and William W. Behrens III, *The Limits to Growth* (New York: Universe Books, 1972); Moore, "Waste in the Limits to Capital."

capitalism, these are shaped by a self-destructive and self-undermining logic: endless accumulation. Virilio's integral accidents are not the mechanical interactions of a complex world-machine, as the cyberneticist would have it. They interpenetrate relations of power, ideology, profit – *and* mechanical systems in the web of life.

Those modern relations emerged and assumed their dominant forms through a historical geography of frontier-making. Thus capitalism's socio-technical antagonisms – nowhere more clearly than in today's capitalogenic climate crisis. These were, historically, offset and offloaded to the degree that the One Percent could move to the frontiers: to extract human and other Cheap Natures; to deposit wastes and pollution of every kind.¹¹⁸ For every technological revolution there must be a place to dump the waste – upon land, sea, and air. Those places include “disposable workers” whose bodies have been enclosed as walking toxic waste dumps.¹¹⁹ When the sources of modern technological dynamism – “the soil and the worker” – are exhausted, integral accidents begin, leading simultaneously to productive exhaustion and ecocide. Militarized “fixes” become more attractive.

What happens when capitalism's sacrifice zone strategy has enclosed the biosphere, underscored by the imperial enclosure of the atmospheric commons as a dumping ground for greenhouse gases? I believe we see it in the Great Stagnation, and its unfolding Great Implosion.

This reminds us of something easily forgotten: technological change is not alchemy. It cannot transmute lead into gold. It is a specific logic, a pathway, of technical change that enables the endless accumulation of capital. Every epoch-making technology has been forged in and through planetary life, nurtured and refined through an imperial strategy that seeks to turn all webs of life into profit-making opportunities.

Capitalism's great technological revolutions never created something out of nothing. The world-ecological storehouse of such stimuli is not inexhaustible – new energy sources, scientific regimes, technical packages and organizational forms cannot be conjured out of the productivity-maximizing magic of bourgeois ingenuity. *These stimuli must come from somewhere.* That somewhere is the frontier – precisely what's been enclosed to enable capitalism's greatest successes. It's this socio-ecological logic of technology, space and nature that must be revolutionized. From what to what? In my view, from a privatized logic of planetary dictatorship to one that favors a biospheric socialism of the associate reproducers. Only then can we navigate the climate crisis through world praxis in the web of life that is democratic, egalitarian, and life-affirming.

¹¹⁸ Robert Biel, “The Interplay between Social and Environmental Degradation in the Development of the International Political Economy,” *Journal of World-Systems Research*, vol. 12, 2006, 109-147.

¹¹⁹ Melissa W. Wright, *Disposable Women and Other Myths of Global Capitalism* (New York: Routledge, 2005); Angus Wright, *The Death of Ramón González: The Modern Agricultural Dilemma* (Austin: University of Texas Press, 2005).