BLOCKCHAIN MACHINES, EARTH BEINGS AND THE LABOUR OF TRUST

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Abstract: *The last decade's developments in computation are major topics of debate among business, policymakers, and social movements alike. Blockchain, Bitcoin, smart contracts, the Internet of Things, machine translation, image recognition, the Earth Bank of Codes – all are understood to be not only business opportunities but also political and environmental issues. Seldom mentioned, however, is the extent to which these innovations are part of an ecological history that goes back to the early 19th century and before. A strategic understanding their dynamics and contradictions requires looking again at long-standing pictures of labour, mechanization, commons, and capital accumulation. Different ways of thinking about Marx's categories of living and dead labour inspired by the work of the later Wittgenstein can help.*[1]

"The only way to grasp the true novelty of the New is to analyze the world through the lenses of what was 'eternal' in the Old."[2]

Slavoj Zizek

"People worry that computers will get too smart and take over the world, but the real problem is that they're too stupid and they've already taken over the world."[3]

Pedro Domingos

Welcome to Nature 2.0

Davos. The World Economic Forum announces a public-private partnership called the Earth Bank of Codes. The Bank would collect digitized information on the genomes and capacities of every plant, animal and single-cell organism on earth and store it securely on the internet in the form of private property that could be quickly found by, and sold to, any business worldwide. Buyers would have to enter into mechanized contracts – also located on the internet – that would automatically and immediately make payments to the property owners whenever their data were used, without going through intermediaries such as banks, lawyers, brokers or even states. Millions of these fast-executing contract-machines would keep track of each use of the data in real time on an encrypted tamper-proof internet ledger, supposedly eliminating the possibility of cheating.[4]

New York. An ex-Trotskyist business strategist and his venture capitalist son go before a Wall Street audience to promote their best-selling book *Blockchain Revolution* – whose subject is the same internet technology to be used by the Earth Bank of Codes. Among the book's assertions is that making cows into "blockchain appliances" could remedy the way globalization has "estranged us from our foodstuffs" by allowing even the most distant consumers to track with confidence the provenance of every animal they eat, while otherwise leaving agribusiness as it is.[5]

Paris. An artist-cum-legal scholar gives a lecture describing how a metal sculpture of a plant can become autonomous, self-sufficient and even reproduce itself. Once imbued with a "spirit" by a "set of resilient, tamper-resistant, and autonomously-executed rules" encoded in software that defines all of its "permissible and nonpermissible activities", she reasons, this "plantoid" will be able to nourish itself by amassing capital from around the world and pay artists for coming up with new versions of itself. More than just a curiosity, the plantoid is an experiment in creating a new kind of organization that could operate more independently of humans.[6]

Berlin. A group of environmentalist visionaries hatches a plan to graft an automated company onto a parcel of land 30 kilometres outside the city to create a forest that owns itself, manages itself, and can act independently of human beings. Animating the forest by enabling it to interact autonomously with machines, infrastructure and the financial system in predictable ways, they suggest, is one way of making real "rights of nature" such as those written into the constitution of Ecuador in 2008.[7]

Environmentalists engaged in grassroots struggles, especially in the global South, may be tempted to dismiss this kind of talk as just too loony to waste time thinking about.

So what if another bunch of mostly Western intellectuals and entrepreneurs are exciting themselves with weird ideas about a mechanized "Nature 2.0"*?* What does that have to do with ongoing battles against extraction, industrial agriculture, climate change, infrastructure projects and corridors, destruction of forest commons, the reinforcement of white supremacy and all the other real threats that social movements face today?

But not to pay attention would be to overlook the leading edge of a politics that is starting to have impacts around the world. One that poses fresh problems for both environmental and labour movements, as well as for movements defending the rights of humans and non-humans.

It turns out, in fact, that the four events mentioned above, marginal as they may seem, help reveal how capital is stumbling its way toward enlisting new forms of automation to upgrade some of its most venerable forces of production: colonialism, racism, patriarchy and the violent division of commons into nature and society.

So what's going on? And how can social movements best respond?

In the search for answers, that mechanized forest taking shape outside Berlin is as good a place as any to begin.

A Cyborg Forest

The plan for the German forest comes in several stages.

First, shareholders buy the forest. Then a contract is drawn up between the shareholders and a "digital representation" of the forest. The shareholders' land is signed over in exchange for stakes in the proceeds from the forest's operations.

The so-called "augmented" forest that results legally owns itself. Via computer programmes, it becomes, bit by bit, an agent, a bearer of rights and duties. As such, it's indebted to its shareholders. To pay off those debts, the forest goes to work managing itself profitably. Once it has transferred enough of its proceeds to the shareholders, it becomes a completely independent economic entity.

Thereafter, the cyborg forest negotiates its own automated contracts with humans or other agents, acquiring resources, making payments, and producing value.

It might contract to get satellite pictures of the property from an external provider. It might hire drones to monitor tree growth and health. After calculating how much timber could be sold each year while maintaining the forest's integrity, and scouring databases worldwide to find the best prices for its products, it might draft logging and transport contracts. Leveraging Google Translate, it could even "consult" with human or robotic authorities on the legal codes of any country it needed to do business with. To borrow the words of one early prophet of such "non-human agents", the representation of the forest is now free "to roam the internet with its own wallet".[8]

Admittedly, the cyborg forest is as yet not possessed of much artificial intelligence. It won't be much of a conversationalist. So far, its actions are restricted to certain kinds of informational and commercial exchange on the internet. From the outside, it might look merely like a rudimentary, electrified version of what Amartya Sen once called the "rational fool" – the fictional, one-dimensional *Homo economicus* the modeling of whose antics has so greatly preoccupied orthodox economists.[9]

Still, to some degree it already interacts with humans "as a peer, not as a tool."[10] At least on the information superhighway, it is capable of earning some facsimile of identity, trust and respect. After all, on the "internet of things", as Nature 2.0 visionaries enthuse, "no one knows you're a forest."[11] Remember that even as early as the 1970s, the simple computer programme ELIZA was mimicking nondirective human psychotherapists so well that it was beginning to be talked about as a possible substitute for its human peers.[12]

As time goes on, as the forest proves its ability to be able to take care of itself, it might even expand and reproduce, independent of the costly labour of human conservationists and safe from the irresponsible impulses of other, more plunder-prone humans.[13] It could begin evolving in creative and productive ways unpredictable to, and even unanalyzable by, humans.

Properly programmed, the new forest-capitalist could even channel the profits it makes into providing people with a universal basic income, in something like the way land, water and forest commons have customarily provided for the subsistence of rural communities.

Once detached from humanity, in short, the cyborg forest would be capable of advancing the dream of the more machine-dazed prophets of the Russian revolution – capital accumulation for the people. But instead of the workers owning the means of production, the means of production would own themselves, freely sharing with humans the abundance that they create. Capital would become like a tree: "just providing."[14]

Smart Contracts: A New Way to Mechanize Human Work

All this might still sound like nothing more than science fiction.

By what possible alchemy could a forest outside Berlin become an autonomous property-owner – a piece of nature that, by being fused with "automated processes", "utilises itself and thereby accumulates capital"?[15]

It's a story that will take up the rest of this article. But one key lies in that contract drawn up between the shareholders and the digital representation of the forest.

This is no ordinary contract, but a "smart contract."

A smart contract is a machine designed to automate and supplant much of the human relationship-work that goes into ordinary contracts, property, ownership and commercial transactions.

Using computer code, clever cryptography, new internet technologies, and enormous amounts of energy, the contract "executes automatically and reliably" after determining mechanically that the right conditions have been met.

So once your contract is safely encoded into the machine, your job is done. You sit back and let automated processes do the work. A smart contract is supposed to make a private property transaction as "fully automatic in its operation once a process is established"[16] as computers were supposed to make a trigonometry calculation. "A smart contract both *is* the agreement and *executes* it."[17] Inscribing your agreement into the proper computer software is no different from enforcing it. "Payment and settlement become the same activity."[18]

Imagine, for example, that you're a timber trader. You draw up a smart contract with your buyers – or, alternatively, just tell a piece of software what kind of contracts you want with your customers and then let your computer negotiate the details with their computers.

Then, when your timber reaches your customers, GPS devices embedded in the shipments electronically alert the smart contract. That triggers almost-immediate electronic payments to you in so-called cryptocurrencies such as Bitcoin.

No invoices, receipts, bills of lading or time-consuming bank transfers. No tiresome disputes or litigation over due dates, contract tampering or ownership.

No trust-building is needed, either. Thanks to advanced post-1970s cryptography, the machine doesn't need to trust or respect anybody or even know who they are. No breach of contract is possible because the contract executes automatically. No cheating is possible because the machine doesn't know how to cheat and wouldn't know how to let anybody else do so, either.

Hence no need to coordinate with greedy bankers or keep obstructive lawyers on retainer.

Potentially, this is a big deal. Contracts in one form or another – between buyers and sellers, businesses and workers, firms and the state and more – are part of the fabric of contemporary society.

If all contracts were transformed into smart contracts, a whole range of heretofore essential "trusted third parties" could theoretically be swept away: not only lawyers, banks, and state guarantors, but also accountants, courts, regulators, notaries public, auditors, registrars, portfolio managers, real estate agents, shipping clerks, credit scorers, insurers, police, and even technical experts like foresters.[19]

That could rev up the neoliberal project of "maximizing shareholder value" one more notch. Like private equity firms, smart contracts aim at stripping layers of workers, management, and maybe even CEOs out of targeted companies in the cause of "efficiency". Once "everything and everyone works according to specific rules and procedures coded in smart contracts", companies would "run with

minimal or no traditional management structure". "Day-to-day decision-making can be programmed into clever code." Rather than working for human beings, subcontractors would be employed by smart contracts that "encode the collective knowledge of management science".[20]

In this delirious vision, employees would be instantly and automatically paid as soon as the machine determined that they had followed the rules. Indeed, somewhat on the model of Uber or Glovo, they would be conceived of less as "employees" than as mini-contractors with minutely-specified tasks and no actionable claims on the smart contract that did not appear in code. They "might not even know that algorithms are managing them", but would be happy on the job knowing that "their assignments and performance metrics" were perfectly "transparent", free of the tyranny of capricious bosses. Consumer feedback would instantly and automatically result in corporate course corrections. Dividends could be paid out in real time, with little need for year-end reports.[21]

In theory, smart contracts could lift commercial relationships out of the stagnant, hoary realm of state guarantees, old-boy networks, banking and legal guilds, word of mouth, paper records, marriage alliances, money-changers, clan and ethnic ties, and webs of mutual obligation and dependency built up over lifetimes of personal and corporate relationships among small, bounded cliques. A functional equivalent of the trust, respect and identity that such matrices supply to elites could be made cheaply available to anybody at the touch of a computer key, with huge gains in economy, security and global reach.

Imagine a world of order without law. Of finance without banks. Of regulation without regulators. Of trust without governments. Of capitalism without corporations or employees. Imagine a world in which you could safely own and trade private property without having to involve other human beings at all. Imagine that you could draw up contracts that were, as much as possible, self-monitoring, self-interpreting, self-verifying, self-executing and self-enforcing, becoming a sort of "force of nature."[22] That's the ideal that smart contracts aspire to.

What Kind of Machine Is This?

The smart contract machine that sits on the internet is obviously a lot different from the machine that sits on the factory floor.

For one thing, it focuses less on production than on exchange. Instead of making it possible to produce huge volumes of *cars*, *paper* or *socks* really fast, with minimal trouble from labour, it's designed to make it possible to monitor, execute, record and enforce huge numbers of *transactions* really fast, no matter how tiny, with minimal human oversight.

In that respect, it's an evolution in infrastructure rather than directly in manufacturing. Indeed, the smart contract machine is increasingly linked to other new developments in infrastructure such as the "One Belt One Road" (OBOR) corridor linking China and Europe.

Second, the labour that the smart contract mechanizes is of a very basic kind.

What your classic factory machine tried to mechanize were specific rule-governed actions of paid workers much of whose labour had already been simplified, divided up and made more repetitive through pre-industrial reorganizations of manufacture.[23] Much of what digitization has speeded up is similar: actions like letter-sorting, data entry or document copying and formatting that humans had

already long been performing in a machine-like way, together with various practices of organizing time that long predate the industrial revolution.

What the smart contract strives to mechanize is something more encompassing and complex: trust, rights, identity, recognition, respect and – in an even more thoroughgoing sense than any factory machine or personal computer – interpretation.

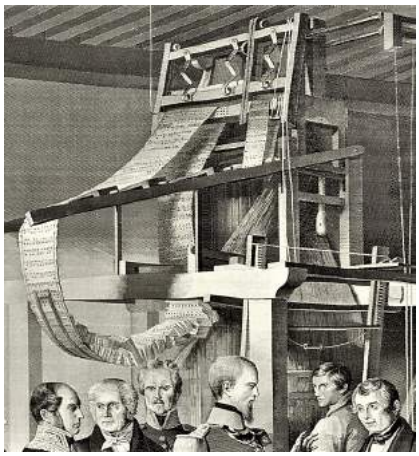
Not just the often-repetitive "symbolic activities" that white-collar, pink-collar and no-collar workers perform on the job, but a larger sphere of unpaid interpretive work that underlies and forms a part of *every* rule-governed act of labour and is grounded in the abilities children acquire – mostly from women – between the ages of zero and five.

For instance, the smart contract is organized around the ideal of fixing in machine form all the ways in which a legal agreement could possibly ever be interpreted. That kind of ambition is unprecedented. It disrupts, to take just one example, the whole idea of a Supreme Court, or indeed any human court. Similarly, some blockchain firms advertise themselves as being able to mechanize not just this or that mental or menial task, but markets themselves – including the relationships of trust that make them possible. "Automating the World's Carbon Markets" was once the slogan of one of them, Infinite EARTH.[24] Along the same lines, some enthusiasts of machine learning describe themselves not as mechanizing any particular laboratory or data-collation chore, but as automating scientific discovery *itself*. Again, this involves mechanizing trust: if you don't trust your scientific colleagues or their scientific apparatus, confirmation of research results is impossible.[25]

Yet the smart contract is essentially just one more manifestation of capital's drive to accumulate by mixing what Karl Marx called the "dead labour" embodied in industrial machines with the "living labour" needed to keep them going. A drive exacerbated by the need to be more productive than your competitors, to realize more value more quickly than they do, to discipline your workers better, and so on.[26]

In essence, the smart contract isn't all that much different from, say, the automated Jacquard loom of the early 19th century, which used punched cards to mechanize the computational skill of human silk weavers, cutting labour needs and undercutting workers' bargaining power at the same time it instantly speeded up production of luxury cloth 24 times.[27]

Or any other machine that has been used to break the power of guilds or labour unions, right down to the "numerical control" contraptions developed to guide machine tools in the 1950s[28] or the "expert systems" devised later on by some early developers of artificial intelligence (AI), which were supposed to encode the knowledge of humans inside computers.[29]



Left: The automated loom invented in the early 1800s by Joseph Marie Jacquard. A precursor of both modern textile machines and the digital computer, the machine was used to undercut the power of the refractory weavers of Lyons. Centre: the Analytic Engine developed by Charles Babbage and Ada Lovelace in the mid-1800s, which built on Jacquard's programming idea. Right: an energy-hungry Google data centre containing thousands of servers – constructed in the tradition of Jacquard, Babbage and Lovelace – as well as electrical and fibre lines and cooling systems.

As one businessman enthuses, it's as if the "lawyer, the bank, the government" is "right inside the [smart] contract"[30] in the form of software, automatically speeding up the circulation of value, avoiding the high cost of litigation, cutting search and transaction costs and reducing the amount of resources each party needs to monitor the other.[31]

And the best part is that you don't have to carry around the crystallized, codified labour of all those lawyers, bankers, judges and bureaucrats around with you in a little box – much less lug around the equivalent of a half-ton Jacquard loom with its boxes and boxes of punched cards.

Instead, it's sitting right out there on the internet on something called the "blockchain", in reach of anybody with access to a computer. (See BOX: "What is Blockchain?") It's as if the little robots that automate all that lawyerly and financial trust work are distributed across the globe in a single machine that in theory everybody can tap into.

As Nick Szabo, the inventor of the smart contract, puts it, it's this decentralization that makes it possible to "substitute an army of computers for an army of accountants, investigators, and lawyers."[32]

Smart contracts, in other words, are part of a longer story of how the repetitive thundering and clacking first heard on the smoky mill floors and construction sites and mines of the 19th century are today being supplemented by the relentless, even more rapid and energy-hungry (if sometimes less noisy) hash operations performed in their repetitive quintillions per second by globally-distributed ranks of advanced computer processing units.

As such, they are part of a story that also includes, as environmental historians have pointed out, capital's continuing attempts to transform sprawling, diverse landscapes into regiments of identical genetically-programmed machines producing single commodities such as cotton, oil palm, eucalyptus, pigs or wheat.

BOX: What is Blockchain?

How does a smart contract mechanize trust and interpretation? And why couldn't anyone invent such a machine before now?

The secret is blockchain, a digital ledger or database scattered across many sites globally yet very resistant to being meddled with.

Each entry in the ledger is timestamped and cryptographically glued to a consecutive series of other digitalized records (for example, records of commercial transactions) in a "block" that's stored in a continually-growing, glued-together chain of other blocks on thousands of computers worldwide simultaneously.

Although this mechanically-sealed, collaboratively-maintained audit trail is very difficult to tamper with, its details can be corroborated by anyone with the proper permission, removing it from the jurisdiction or censorship of any central authority or proprietor. All this became possible only with post-1970s cryptography, post-1990s computer hardware and software, and continuous increases in energy extraction and production.

The data maintained and protected on a blockchain can be of many kinds: commercial records, digitized genomes, music, land titles, patents, digitized customary knowledge of indigenous peoples, art, bills of lading, carbon credits, even votes. Some of this information you can search for and get access to only if you have accepted the terms of a smart contract that is also stored and executed on the blockchain.

From Information to Currency

Blockchain's first claim to fame was that it made the internet into a place where you could store and instantly transfer capitalist value as well as information.

On the old internet, it was easy to send a digital image of a $1 bill to a million people, while still holding onto the original yourself. But transferring a "real" dollar was different: you had to prove you didn't still have the $1 yourself. (Or not: in state-regulated carbon markets, carbon credits are often spent two or more times.) In the past, that required a bank or other third party to step in to verify the electronic transfer – and collect a fee along the way, of course.

Blockchain changed that by putting such transactions into a supposedly secure, immutable, inspectable digital record shared among thousands of separate nodes. That allowed people to transfer not just information but also value to each other directly yet securely, "peer to peer."

Contrary to the dictionary definition, this "peer" might be somebody that you had nothing in common with except for your blockchain connection. He or she didn't have to be any more of a "peer" than the anonymous stranger you hand a dollar bill to.

The difference is that the blockchain transfer would be a lot more secure than that. If you give a dollar bill to a vendor on the street, a thief can run up, grab it, and make a getaway. Even if you use a bank to

make the transfer, you're putting your money in a centralized location that can be hacked, burgled, snooped or targeted by financial swindlers.

With the blockchain, such shenanigans aren't so easy. Because its database is divided among thousands of locations worldwide, robbing you of your money is a lot harder than breaking into a bank. As blockchain executive Jamie Smith says, it's as if "you now have to break into an entire town."[33] Even better, the system gets more secure the more complex it gets (and the more energy has to be used to keep its machines going).

Enter Bitcoin, the famous independent digital currency, which since 2008 has grown to constitute over $100 billion of the world's money.[34]

From Currency to Contract

But if the internet can now be used for nearly-instantaneous, seemingly intermediary-free transfers of capitalist value, why stop at Bitcoin? Why not move on to non-currency items like land titles, valuable art works, and biodiversity assets?

After all, capital always needs to find new forms of mechanization to try to free up the circulation of value, whether that means building faster and bigger container ships to carry goods or investing in customer-tailored advertising on Google. It needs people to buy stuff as quickly as it's produced or located. And people to reinvest in more production and cheap extraction as soon as possible after that.

What a boon, then, if you could have at your disposal not only an interactive database in the sky in which people and machines could continuously exchange information bits securely, apparently without intermediaries, and not only peer-to-peer currencies, but, on top of that, another device in the sky that could mechanize all the social and political relations involved in the ownership of anything, making it possible to locate, secure, trade, lend, manage, monitor and insure value in any amount at almost any speed!

In the visions of some of its more feverish prophets, blockchain not only could someday provide solid, incorruptible information to anybody or any machine about the real-time status of anything connected to the "internet of things" that now links together millions of devices and people around the world. Via a super-secure "digital barter" platform, it could also make any fraction of any entity anywhere – half a live chicken in Honduras, a third of a customary irrigation system in Pakistan, a quarter of the solar electricity produced on a rooftop in Uganda – instantly and cheaply exchangeable worldwide for any fraction of anything anywhere else.

That could help release a continuously-flowing tide of liquid assets the likes of which has never seen before.

Something for Everybody

Capital sustains itself only by constantly venturing into new territories. When it comes to what Joseph Schumpeter called "creative destruction", its best friends are often people standing outside the mainstream, people dissatisfied with the status quo and sometimes with a rebellious axe to grind. It's by

owning “disruptive” knowledge and technologies like blockchain and smart contracts that the fortunes of contemporary information tycoons are made.

Thus both technologies were pioneered not by calculating business executives but by an assortment of libertarian computer nerds, cypherpunks, far-right crypto-anarchists, techno-hippies, New Agers, artist-hackers, and other free-spirited individualists. To quote computer expert David Gerard’s cruel if irresistible caricature, many of these innovators are geeks who have no “aptitude for social or legal conventions, but do have an aptitude for programming, so they’d like social and legal conventions to work a bit more like that” and “anarcho-capitalists who want to replace the government with a small DOS batch file.”[35] Some, too, in common with the figures behind Facebook and Google, have a history of being supported by the fanatic anti-feminist billionaire Peter Thiel, who has gone on record criticizing the right of women to vote.

But the smart contract idea of mechanizing away parasitic intermediaries strikes a chord with many ordinary people as well.

Is there anyone, after all, who hasn’t at one time or another found themselves agreeing with Charles Dickens’ Mr Bumble that “the law is an ass”? And who hasn’t been outraged – particularly after the 2008 economic crash – by the tricks financial intermediaries use to enrich themselves without doing any productive work? Or by the market power they hold just by virtue of their monopoly “tollgate” positions?

Who isn’t concerned, similarly, about the way companies like Facebook and Google are ripping off the unpaid work that their users do in describing themselves and repackaging it for sale to advertisers and political candidates?[36] Or about the way that banks and states use centralized power and technology to monitor us and decide unilaterally whether we are good credit risks or good citizens?

And who hasn’t been frustrated by the obstacles bureaucrats love to throw in your way while pretending that they’re “just following the rules”? Or been pushed around by children of elite families whose surnames alone provide them with the leverage to build giant fortunes?

Maybe smart contracts, some suggest, will offer ways for the suffering multitudes – all those unsung “peers” of prospective “peer-to-peer systems” – to get out from under this kind of abuse. Now, perhaps, everybody can benefit from a democratized equivalent of the corrupt, exclusive “commons” previously available only to big business insiders and their intermediaries. Finally, perhaps, a capitalism for the people, not just the cronies. Let’s give banking services to the unbanked. Let’s give security to the insecure. Let’s get little guys into venture capital alongside high net worth individuals. And without the need for so much state-backed infrastructure and safety nets, maybe we can get rid of taxes too. Machines will make us free.

A sober, nuanced assessment of the meaning of smart contracts, however, can’t restrict itself to the happy democratic – or anti-democratic – dreams of their originators. It also has to investigate the concrete ways that smart contracts, released into the wild, integrate into, transform, and are transformed by, actually-existing capital. Business – which knows, deep down, that all profits ultimately come from subsidies – looks at blockchain mainly with an eye to how it might capture more of them. And at the present moment, it is business, not popular movements, that is putting more effort into trying to understand and steer blockchain.

Here close attention needs to be paid not only to what smart contracts do to enhance profit directly, and to whom they do it, but also to what they do not do. We need to inquire not only into how blockchain – like previous instances of industrial mechanization – helps appropriate the unpaid work of both humans and nonhumans, but also to what extent it fails to do so, and how this failure conditions its success.

The Appeal for Business

For mainstream capitalists and financiers, the attractions of smart contracts and other blockchain applications are several. They include the following.

- ***Savings in search, verification and transaction costs***

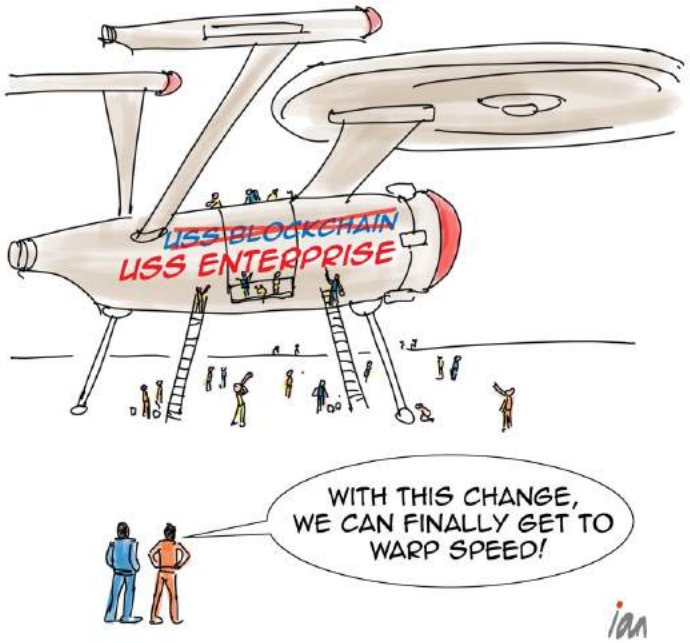
Blockchain gives economic actors a shared infrastructure of virtually indisputable data on transactions that doesn't rely on conventional trusted intermediaries or toll-collecting gatekeepers. That can make it easier and cheaper to trade your property or set up your own secure digital platform.

Smart contracts are also advertised as being capable of drastically cutting legal expenditures on contract disputes – which amount to as much as half of all litigation in the US and UK. Ideally, they eliminate the possibility of breach, forcing parties to honor their agreements and even making it possible for them not to have to spend money monitoring each other. Blockchain might also make credit cheaper if it makes property more liquid. According to a report for the Massachusetts Institute of Technology, by 2016, more than 60 per cent of the global financial system had already entered into a consortium to apply blockchain in order to save costs.[37]

In addition, what with automated detection and secure recording of shipment movements and transfers, inventory alterations, insurance data, toll and tax payments, and so forth, blockchain is bound to be a useful economic lubricant along the globe-spanning sea and land pathways followed by the 40-foot containers that carry much of the world's traded goods, as well as what might otherwise be transaction-clogged border-crossing infrastructure corridors such as China's OBOR project. Unsurprisingly, OBOR is already entering into partnerships with blockchain and artificial intelligence firms such as Matrix AI.

- ***Speed***

Blockchain and smart contracts can cut cross-border financial settlements from days to seconds, and, by accelerating the rate of transactions, enable projects to get under way faster. Tasks that used to require different institutions, like recording, auditing, clearing, settling and reconciling, can be collapsed into a single step, drawing interest from companies such as Maersk, Evergreen Marine and Anheuser Busch.[38] Banks such as HSBC and JP Morgan are using blockchain to speed up currency exchange and client payments. Firms such as Infinite EARTH hope that sluggish, broker-clogged transactions in ecosystem service tokens can also be accelerated through blockchain, and questions about their environmental validity sidelined.



- ***Labour discipline***

In addition to attempting to automate the compliance of every individual worker with tailor-made, worker-specific, non-negotiable sets of preset encoded rules, smart contracts promise to minimize the dependence of employers on workers' knowledge. As one supply-chain executive puts it, the hope is that "by utilizing AI and predictive analytics technology, the optimization of deliveries is shifted to algorithms rather than tribal employee knowledge."[39]

Capital's fascinated dread of that "tribal employee knowledge" – and the term "tribal" is extremely revealing – is, of course, a fixture familiar from every past era of capitalism. It can be no surprise to find it reappearing in the blockchain age in pretty much the same form it appeared in, for example, the statements of early prophets of industrial capital such as Richard Arkwright or Andrew Ure, who noted in 1835 that "the more skilful the workman, the more self-willed and intractable he is apt to become, and, of course, the less fit a component of a mechanical system, in which, by occasional irregularities, he may do great damage to the whole".[40]

In addition to reducing the bargaining power of many classes of worker, blockchain also has the potential of taking much of the heat of public blame for social problems off capitalists and managers: "It was the algorithm that did it. We just need to regulate the algorithm more." As law professor Lauren Henry Scholz puts it, "[w]hen algorithms are introduced in institutional decision-making, individuals outsource their valuation processes to the algorithm"[41] – an act that is itself a key form of living labour. The more that big data appears to be "organizing itself," the more this dynamic tends to take hold.

- ***Ability to help capital reach into millions of small spaces scattered across the globe and make new businesses possible where there is at present a "trust deficit".***

To blockchain prophets in finance, today's banking sector still reeks of the 19th century, with its ranks of ink-stained, Barnaby-like scribes on stools and booze-fuelled schmoozefests among fat deal-makers

with stickpins in their ties. Despite the nanosecond transactions enabled by supercomputer-powered automated trading and the 1990s re-fusion of conventional and speculative banking, finance remains pretty much all thumbs when it comes to the profitable integration of tiny customers and tiny investors into global capital flows. The excess of humans in back-office operations, clearance houses, database maintenance and auditing activities is both cause and symptom. Automated micromanagement is now ready to ride to the rescue. With blockchain, banks can safely put hundreds of millions more poor people in debt while making it simpler for them to invest in anything from consumer goods to carbon credits and to send cash instantly to family members without fees or trust in traditional intermediaries.

But it doesn't stop with banking. Blockchain and smart contracts also help transform into resources millions of idiosyncratic little things around the world that were previously difficult to commodify, like the natural germicide produced by a species of Amazon frog or informally-held rights to half a hectare of local forest commons. They make it possible to "digitize and monetize natural capital" faster, more easily, and more securely, helping to convert both *pachamama* and nature conservation more thoroughly into something that a wide range of actors can buy and sell in the form of exchangeable tokens.[42]

Take, for example, the 2010 Nagoya Protocol. Nagoya is supposed to ensure the "fair and equitable" sharing of benefits arising out of the capitalization of genetic resources. In other words, to curb biopiracy. But how do you do that without freezing up the circulation of biodiversity assets so much that nobody makes any money – or even bothers to catalogue or collect their genetic property in the first place?

Secure blockchain platforms offer a possible answer. If wary Southern nations know that no corporation can gain access to information about their genetic resources without signing smart contracts that automatically enforce rights and obligations governing their use – and that will mechanically and securely channel a bit of the returns from any attempt to commodify their digitally-fingerprinted DNA sequences back to the source – they may be more willing to monetize their biodiversity. And maybe wary capitalists will be more willing to take the necessary risks if they're provided with a gigantic "eBay-like global marketplace" for intellectual property that "reduces the search and transaction costs between providers and users" of juicy bits of indigenous knowledge from the Amazon, the Western Ghats, or anywhere else.[43]

Or take the longstanding project of Peruvian businessman and neoliberal icon Hernando de Soto to bring the vast but fragmented untitled lands of five billion of the world's poorer people into the circuits of capital.[44]

Among the advantages of this project – undertaken, predictably, with the approval of the World Bank – was that it promised to help provide mining corporations, agribusinesses, carbon traders and various developers with less risky, brutal and unpredictable means of dispossessing inconvenient peasants and commoners and making them work harder for capital. The catch was that transforming every little piece of that informally-held land into a recognized, standardized unit of tradable private property was always going to be a tough job, bureaucratically speaking.

Imagine, however, how much easier the job becomes with blockchain, which, by recording and automatically enforcing all those diverse informal rights in an incorruptible digital public ledger, is theoretically capable of rendering every little squatter's patch of land tradable on a global marketplace.

Why shouldn't de Soto be delighted, then, to accept an invitation as guest of honour to the First Annual Block Chain Summit in May 2015, co-organized by British tycoon Richard Branson on his private Caribbean island?[45] And why shouldn't countries eager for capitalist development like Georgia follow de Soto's advice and consider putting their entire land registries on blockchain?[46]

Because of blockchain's ability to compile, secure, and update in real time every little bit of information about business risk, health risk, disaster risk and weather risk worldwide, it also promises to help insurers commodify uncertainty more profitably. With a fast, reliable global database constantly feeding fine-grained risk data into millions of automatically self-adjusting individual smart contracts, the chances could be reduced that less vulnerable customers – or insurance firms themselves – will end up subsidizing customers that the companies learn too late are more risky than they thought. The large, crudely-rationalized "risk pools" that the insurance and welfare sectors have had to work with in the past in order to spread costs and exposure and stabilize premiums – and to make possible coverage for high- as well as low-risk customers – could become more and more outdated.

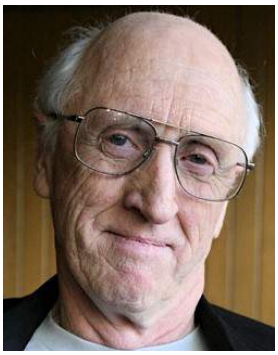
Nor does it end there. Blockchain also vastly extends the frontiers of "prosumption" – capital's 20th-century strategy of organizing and exploiting the unpaid, informal labour of customers by appropriating their freely-given feedback, personal data, design ideas, reviews, "likes" and "dislikes" and transforming them into privately-held, big-data commodities for sale.

As elsewhere, blockchain adds a seemingly egalitarian twist to this old form of extraction: smart contracts could make it possible for some of the growing numbers of these unpaid workers, at long last, to get a piece of the action for themselves. That is, instead of algorithm-owning firms becoming the sole proprietor of the "virtual you" that they create out of your data, you can be doled out a share as well. You still don't own the machines needed to produce this "you-commodity", but you do get a bit of the proceeds.[47]

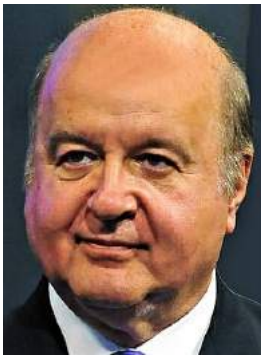
In 2018, for instance, a Korean company called Cosmochain launched an Ethereum-based project to integrate the work of thousands of individual customers more intimately into cosmetics producers' accumulation strategies.[48] Consumers provide information about their skin, behaviour, product preferences, and so on. This is aggregated on blockchain for sale to cosmetics firms to help them develop and market products. In return, consumers automatically get Cosmo Power, which, on the model of air miles, can be converted into tokens that can be used to buy cosmetics online.

In the future, similarly, a company like Nike could create smart contracts that would automatically send micropayments to every buyer of its shoes in exchange for the information that electronic sensors in the shoes would collect about that particular customer.[49] Here, too, blockchain promises to help capital learn how to reach into ever smaller pores of the life of humans and nature, opening up micro-frontiers it had never before realized were exploitable.

BOX: Blockchain Nerds and Prophets



Clockwise from top: Satoshi Nakamoto (shadowy libertarian genius behind Bitcoin), Nick Szabo (reclusive libertarian inventor of the smart contract), Vitalik Buterin (developer of the Ethereum smart contract blockchain platform), Juan Carlos Bustillo-Rubio (entrepreneur and promoter of the Earth Bank of Codes), Hernando de Soto (trader, World Bank consultant and organizer of neoliberal movements in Peru and elsewhere), Primavera de Filippi (Harvard-associated legal scholar pioneering blockchain-powered "plantoids"), Trent McConaghy and Jan Peter Doomernik (hackers and Nature 2.0 promoters), Don Tapscott (ex-Trotskyist turned business adviser), Michel Bauwens (left-wing champion of blockchain commons), Stewart Brand (Californian counterculture guru and corporate consultant).



The Flip Side

If there's one thing that 19th-century industrialism revealed, it's that machines can't serve capital without constant, cheap infusions of the "blood" and "vitality" of free-range human and nonhuman activity.[50] Only through continuous, low-cost, but ever-precarious subsidies from "nature, colonies and women"[51] – as well as from the "baseline communism"[52] that children learn from a very young age – can robots, computers and mechanized metal punches overcome entropy and work their economic wonders.

Thus steam engines, turbines and dynamos could never have put the world to work accumulating capital for industrial companies without the low-cost input of centuries of work by living organisms beavering away at converting solar energy into coal, oil and gas.[53] Highly-capitalized refineries and chemical plants could never break even today unless black and brown fenceline communities – together with the rest of the global society of living beings – offered up their bodies free of charge as repositories for industrial pollutants.

Nor could industrial capital survive a single day without continually seeking out fresh, proportionate quantities of new human labour in order to maintain, repair, clean up, update, adapt, check, de-digitize, reinterpret, excuse, manage the wastes from, supervise the learning of, and generally make usable the actions that machines accomplish for society – even, where necessary, by adjusting human actions to conform more closely to a machine model. The more potentially golem-like[54] machine or machine-like operations you have, the more living labour you need to ensure that they interface productively with society and nature and don't go "feral", becoming sorcerer's apprentices. The longer and faster you try to run machines or algorithms without enough of the right kind of living labour to tend them, the greater the chances of failure for business itself.

Nearly a century after Marx, Ludwig Wittgenstein's work helped update this Marxian "contradiction" in a way that helps show why it's still relevant in an age of computer-mechanized law and renewed struggles over the commons. Together with the research of followers such as the sociologist of science Harry Collins, Wittgenstein's work also suggests a way of ridding it of the overtones of an archaic vitalism that trouble some critics.

Wittgenstein's "rule-following paradox" states that rules – which can be taken to include the patterns of motion that both 19th-century steam-driven machinery and 21st-century computers are designed to repeat at high speeds using thermodynamic energy – are useless in the absence of people who can work out when they apply and when they can be broken (which is why "work to rule" is such a powerful weapon of labour resistance). And similarly for any second rule anyone might formulate about how to interpret the first rule; and so on.[55] To put it another way, any rule needs human communities constantly deciding and re-deciding what it is for it to be followed or not followed.

Seeing Steam Engines in Computer Processors, and Vice Versa

Wittgenstein's paradox is a useful lens for bringing into focus the continuities between smoky 19th-century factory machines and the slick 21st-century electronic engines driving Google, Amazon, Facebook, Bitcoin and Ethereum.

Everybody knows that early industrial capital had to churn through armies of uprooted living labour to get itself off the ground. It needed human workers – largely, and recurrently, from rural areas – to tend mechanized looms, maintain and clean up locomotives and dynamos, keep engines fed with raw materials, and also shut them down when necessary.

To those on the scene, it sometimes might have seemed that all these relentless industrial devices were, to quote Marx's words, threatening to act completely "in independence of [living] labour".[56]

But that was only an appearance. As Tony Smith notes, living labour (inside which lies the commons) has itself always been "'inside' capital all the way down".[57] Even the woefully machine-bullied worker played by Charlie Chaplin in the 1936 comedy *Modern Times* was a type of input – even if replaceable – that the assembly line couldn't do without.

Today's workers still take care of the kind of machines that Chaplin battled with. But they also have to serve computers. And they serve them in pretty much the same way.

Wittgenstein showed that evolving human communities are "inside" even the simplest rules of calculation, the simplest signposts, the simplest codes. So, too, must they be "inside" all the complex mechanically-executed algorithms and deep-learning programmes that drive word-processing software, Google Translate, artificial intelligence and smart contracts – just as factory workers, and the experience their ancestors had built up over centuries, were "inside" all those sprawling 19th-century mills and 20th-century car factories.

In short, today's information capital, like its predecessors, can't do without unceasing torrents of the living work of humans raised and continually nourished in evolving commons environments. Except that this time the human job is to bring to economic life the high-speed execution of "dead" algorithms by energy-hungry graphic processing units rather than just the actions of locomotives and dynamos.

Naturally, a lot of this happens toward the bottom of the social pyramid. In DHS delivery trucks, to take one example, human drivers constantly have to contribute their living labour to correct and adapt the output of their GPS pathfinders. On the capitalist margins, meanwhile, human recyclers, or neighbours of mining and energy operations, are forced every day to work to cope with the wastes and toxins of the digital age.

But this is only the beginning. Without being paid, hundreds of millions of people digitize thousands of pieces of their own lives every day, preparing inputs for proprietary learning algorithms driven by high-speed computer processors. Free of charge, they – we – are incessantly translating into strings of ones and zeros what we said to our friends over dinner, what the baby did yesterday, what we chose to buy just now, what we think of Modi or Duterte.

Nearly every time we open our smartphones or computers, we also do unwaged work labeling thousands more pieces of information that are already digitized and circulating on the internet, helping the algorithms register that the video our cousin sent us yesterday is indeed a cat video and not a dog video, or that, in an Ecuadorian restaurant, a translation of *tigrillo* as "little tiger" is likely to be regarded as a funny mistake. Collectively, we computer users also deliver at least half a million hours of unpaid consulting labour daily to various companies whenever we, for example, classify images in order to complete those anti-robot "CAPTCHAs" (short for "Completely Automated Public Turing test to tell Computers and Humans Apart") that allow us access to various websites.[58]

In accepting such tasks, we also work with machines to reconstruct our own selves as what the sociologist Dallas Smythe calls "audience commodities".[59] Based on the quantifiable, digitally-readable trove of raw material that we, as living labour, help organize, this audience commodity is then sold to advertisers, political operators and others. Because no outlay on salaries is needed, every minute of this work translates into more or less pure profit for firms like Google, Facebook and Amazon. Without this newly-recruited human labour, the advanced, energy- and mineral-intensive machines owned by such titans of the "knowledge economy" would be so much junk.

Facebook, for instance, in addition to relying on the cheap labour and slavery organized in China and elsewhere to make computer hardware, has around 35,000 of its own paid employees. But it has over two billion unpaid users, many of whom spend an hour or more every day working for free for the company. On the most conservative calculations, that means that the hours of work that the company extracts from its customers outweigh the working hours of its waged staff by well over a thousand to one. Similar calculations can be performed for Google, Amazon, Microsoft, Apple, IBM, Alibaba, Baidu and Tencent.

Spare a thought, too, for the machine-animating labour expended by the notoriously wealthy one per cent. Banks, hedge funds and pricey law firms depend just as much on the living labour of their wealthy staff to keep the rents flowing in, and never more so than in the computerized present.

Post-1973, for example, thousands of traders in the world's financial districts were pushed to hitch their fortunes to mechanized equations like the Black-Scholes option-pricing formula. Post-2008, at least a few of the same traders had to turn around and reeducate themselves to *stop* pretending that their brains could be pretty much replaced by automated algorithms.[60] The re-education can take longer for apologists for mechanized finance such as Alan Greenspan and Gordon Brown.

Today, the industry is remechanizing, as deep learning devices and computer engineers invade empty spaces at Goldman Sachs once packed with human traders.[61] But whatever the ups and downs involved, the question is never *whether* living labour is needed to interface with dead labour, but *how* it is to do so. In that respect, the mechanization issue on Wall Street isn't that much different from that in the "satanic mills" of 19th-century Manchester.

The same goes throughout the production, consumption and "prosumption" regions of today's economy. Whether or not you accept a Google-generated suggestion about how to complete your email text, or try to "game" Google searches, you are making a decision, as living labour, about how to tend or "comb" an algorithm running at high speed on a mechanical device – a device that in turn uses or is composed of substances that owe their vitality to million-year living histories that preceded their being torn by other machines from the fabric of someone's water source or cultivated territory.

Similarly, no matter how thoroughly McDonalds attempts to automate its checkout process in order to make it easy to replace and oppress its human staff, it will always need more of them – who, no matter how young, have years of socialization and ingrained skills in dealing with unpredictable situations – to provide an interface between its simplified cash registers and its hungry customers.[62] So, too, when, in 2017, Israeli police decided to trust a mistaken automated translation of يصبحهم as "attack them" instead of "good morning" and arrested an innocent Facebook poster as a result, they were choosing *how,* not *whether*, to bring their own living labour into interaction with a machine.[63]

This living labour, and the commons in which it is embedded, have no fixed form. And, like their early Industrial Revolution ancestors, both continually evolve in machine-rich as well as machine-poor

environments. Consumers' "click activity" on the internet and efforts to build Facebook relationships are as much a part of the body of living labour as the worker comradeship and boss-baiting that indirectly helped keep urban assembly lines functioning and profitable,[64] or the subsistence supplements that many workers in the global South continue to receive periodically from rural-based cousins tending fields and collecting forest mushrooms. The human activities that capital needs are never really separable from from other-than-human activity in the commons. In the information age, those activities continue to include heterogenous forms of resistance itself, which capital not only cannot ever fully overcome but also can't do without if it is to "expand its ability to imagine abstraction and to extract the most value from this capacity," to quote historian Dipesh Chakrabarty.[65]

In reality, then, the blockchain age signals not the end of industrial capitalism nor of the exploitation of labour, but its expansion and evolution. High-speed, high-output machines operating with "dead" rules are not disappearing, but proliferating. Human workers must do likewise and accompany them wherever they go, continuously modifying themselves in the process. Prominent venture capitalist Marc Andreesen is one ex-coder who has little doubt about the shape of the labour future: "The spread of computers and the internet will put jobs in two categories: people who tell computers what to do, and people who are told by computers what to do."[66]

So forget the proclamations of pundits on both the left and the right that that we live in a "post-industrial" age that is at long last "moving beyond work". Forget the idea that today's "information economy" is becoming "immaterial". Forget Bill Gates's "frictionless capitalism." Forget the "automated luxury communism" heralded by some leftists.

As Marxist scholar Salvatore Veca summed it up years ago, capital "is not objectified labor *tout court:* it is objectified labor which is exchanged in a certain way with living labor,"[67] which becomes "internal" to the "dead labour" represented by automation. In the end, increased efficiency and productivity via mechanization is just another name for capital's repeated mobilization of free handouts from novel sources.

The Dead and the Living

The key question for the history and the ultimate fate of capital is what *happens* in various eras when cheap or zero-cost living work – whether human or nonhuman – is adapted and fused with industrial machines for the sake of accumulation.

Marx had a lot to say about the 19th century's experience in this regard. What he said helps in understanding the digital age as well. But does our experience of 21st-century phenomena like blockchain enable us to go further than he did? And perhaps to look back with new eyes at his own experience?

Information technology brings into sharp focus an ecological aspect of capital that has tended to be obscured both by business hype about "everlasting progress" and by shallowly anti-capitalist diatribes about how everything that is "traditional", quaint and environmentally wonderful is melting into air at the hands of capital. This is that capital is compelled to look to the future mainly with an eye to how it might be dominated by scaled-up caricatures of one or another feature of the past. The subordination of living labour to computer networks under capitalism – like its subordination to factory machines – is not well described by saying that workers are struggling to adapt to a whirlwind of innovation sweeping out of the future. It is better described as suffocation wrought on a daily basis by capital's

need to impose on them a hypertrophied, simplified, crystallized, deadening yet rapidly-repeating version of the past.

In other words – and this is to overturn the usual cliches – capital oppresses human and nonhuman workers not so much by trying to push them too quickly into a more efficient future, but by using thermodynamic energy to shackle them to a turbo-powered dead past against which they must constantly struggle. Only via the subjection of living labour to masses of frozen, sterile, amplified distortions of past actions, via the thundering or flickering repetitions of pistons or microchip circuits, can capitalist value be created out of a human legacy that is compressed and denatured in the process, and surplus amassed within the time periods mandated by competition.

Many left activists and scholars are rightly making a lot of noise these days about how deeply contemporary capitalism is dependent on thieving the fruit of society's "general intellect" – its collective creativity and invention – and then privatizing it and extracting rent from it using legal means rather than engaging in the actual production of new capitalist value.[68] Thus was born a good part of the fortunes of six out of the ten richest individuals in the world today: Jeff Bezos, Bill Gates, Mark Zuckerberg, Larry Page, Sergey Brin and Larry Ellison.

However, it's not incidental that the staggering wealth of all these men is associated with machines as well as with legal larceny. Machines that work pretty much in the old tradition of 19th-century industry.

The old factory machines took embodied knowledge and skills from pre-industrial pasts, clipped out certain parts, and standardized and amplified them into what Marx called an "iron man confronting the man of flesh and blood"[69] with relentless physical repetitions that were like a vicious, exaggerated parody of the rule-following actions of artisans.

The new electronic machines start with the same kind of knowledge from the past. Again, they chop out certain pieces. They then use living labour to change these bits *en masse* into measurable, machine-ready digital entities that can be subjected to repeated, rigid, super-fast physical operations. As before, these machine operations confront human workers like a giant parody of older rule-following socionatural interactions.

But the range of the interactions subject to automation attempts has now enormously expanded to include things like trust-building, translation, recognition, negotiation, decision-making and human care of and respect for animals and plants. To quote the manifesto of the ill-fated "totally-automated" corporation known as The DAO, which was supposed to run on a smart contract that did not "require or allow human intervention or interpretation," these types of work, too, are now being envisaged as increasingly subject to the "steadfast iron will of immutable code."[70]

"Parody" is an apt description in both cases. For example, the "translation" of today's machine translation is not translation as conventionally understood but rather a turbocharged mechanical version of *prediction*.[71] Google Translate has no more understanding of linguistic structure or rules than a 19th-century wheel-making machine had of human wheelwrights' skills in making wheels. What it does with such impressive accuracy – particularly after November 2016 – is predict very cheaply, using unprecedently large masses of digitized historical evidence, 100-million parameter regressions, and self-evaluating programmes, how a human translator would match a sentence in one language to a sentence in another. Treating text as a "classification problem instead of as an understanding problem",[72] it is indifferent to what languages are for or how they evolved. The better its quasi-translations get, the harder it is for humans to trace or understand how they were arrived at.

Smart contracts' interactions with financial institutions, similarly, would substitute high-powered mechanical prediction for the human judgment of businesspeople and financiers. If they make possible "disruptive business models that were unheard of ten years ago,"[73] it will be because they duplicate this judgment, but because they replace it with something else.

The potential of brute-force prediction has become realizable only because of three interdependent technological developments of the last decade. First, the revival of 50-year-old neural-net or deep-learning approaches to artificial intelligence, through which software can continuously teach itself what algorithms are best at predicting whatever it wants to predict.

Second, the construction, via lots of human work, of vast libraries of digitized, measurable bits of information out of centuries of undigitized flows of human culture – for example, libraries of human-labelled and -organized JPG images[74] or encoded sentences in many languages. These constitute much of the raw material out of which the machines construct their predictions.

And third, the continuing jumps in processing speed that enable computers, for the first time, to convert these mountains of data into cheap, accurate predictions in very short times.

Thus Google Translate gloms onto billions of digitized, machine-ready sentences out there on the internet – representations of oceans of the living work of past generations of humans and nonhumans. It then subjects this "big data" to unprecedented computer power to predict – probabilistically rather than linguistically – what the most acceptable sentence-to-sentence equivalences are likely to be. And it constantly corrects its own procedures on the basis of new data.

In order to be able to provide so many "translations" so fast, the whole parodic process requires amounts of energy that dwarf those required for human translation – just as the factory machines of the 19th century required mobile, interconvertible energies on a scale that workers hadn't before imagined in order to perform their rapid, heavy-duty mockeries of previous manufacturing methods.

The same goes for today's image-recogition algorithms. Software can "recognize" a photo of Elvis Presley and distinguish it from photos of Elvis impersonators only after thousands of pictures of Elvis – and pictures that are *not* of Elvis – have been laboriously clipped by humans out of the flow of past popular culture, labeled, digitized, and churned through energy-intensive mechanized learning algorithms.

As with the blockchain with which it is increasingly linked via smart contracts and the "internet of things", artificial intelligence's efforts to minimize human work and maximize productivity requires industrial-scale extraction and conversion not only of myriad bits of the culture of the past, but also of the resources required to "reanimate" the results and get them moving around strange new circuits at unprecedented velocities.

Capital's Struggles with Itself Regarding Time

Whatever their self-correcting, self-updating abilities, the new mechanized prediction algorithms, like their 19th-century prececessors, can never become more than what Marx called "dead" labour if they are to function effectively for capital.

These new "dead" entities – or maybe we should say "undead"? – update a longstanding political struggle having to do with time. Leaving in the dust technologies like rhyme, song, writing, dictionaries and grammar books,[75] blockchain and devices such as Google Translate greatly develop capital's reflexive, recurring attempts to establish the hegemony of a dead past over an open-ended future.

To understand why, it's useful – as with so many topics regarding labour – to turn to children.

Before children can talk, they point. They want their mummies and daddies to see their interest in something and to move them closer to it. They want in on the action. They're prepared to open a conversation with the world without needing to know exactly where it might take them. They want life to move toward experiences, including words, whose meaning is in the making. Their pointing is directed not only at something outside themselves, but also toward an open, indeterminate, interactive future. A future, moreover, that, despite their impatience, tends to unfold only at a certain pace. Children's explorations, moreover, are grounded in a trust that is built up unconditionally, that is, not by constructing indefeasible if-then conditional propositions.

The lesson applies to adult life as well. In passages on machines and meaning written in the earliest days of the computer age, Wittgenstein was already trying to traverse some of the characteristic, ingrained, self-contradictory fantasies that later came to underpin blockchain, smart contracts and other features of digital capitalism. Speaking of adults, he noted that "when we mean something, there is no dead picture here (no matter of what kind), but, rather, it's like going towards someone."[76]

Like a child's finger, Wittgenstein noted, an arrow on a signpost points "only in the application that a living creature makes of it"[77] according to "an established usage, a custom."[78] Everything works fine not because there's something inside the "dead picture" of the arrow (or, for that matter, its digitization as a series of ones and zeros in a JPG image of an arrow) that compels us to move one way rather than another. Or even compels us to understand what the words "one way rather than another" might mean.

Rather, the arrow works to guide us because of two realities surrounding it. One is that "under normal circumstances," our long socialization as children among our family and small friends enables us to "know how to go on" creatively when confronted with the signpost in a way that will get us where we think we want to go.

The other is that this skill of "knowing how to go on" can never become more than a provisional, "more or less" kind of understanding. If there is a roughly "normal" way to go on, there has to be an "abnormal" way too. Otherwise the whole show falls apart.

That is, there must always be a possibility that, given as-yet unforeseen events, the arrow would come to "say" to us that we should go in the direction of the feathers, not the point. Nor can any signpost definitively show "which direction I am to take after I have passed it, whether along the road or the footpath or cross-country." Unlike a smart contract, the signpost, to fulfill its purpose, must be something that "sometimes leaves room for doubt, and sometimes not."[79] Its success rests on the fact that it doesn't even try to eliminate the possibility of uncertainty or cheating or approach the ideal of an autonomous order without law. Its workability is not a function of how closely it "approximates" the goal of making trickery impossible. It's like a promise, which has practical significance only in the sense that it could conceivably be broken, while society would still "know how to go on".

You can't "fix" this indeterminacy by adding more signposts along the route, until only one "correct" course of action is left that will uniquely determine travelers' actions for all eternity. After all, the same

question can be asked about any of the new signposts. Or about any weatherproof manual on "how to interpret signposts" that you might care to tack onto each one. Or about any manual about interpreting manuals that you append to the first manual. The indeterminacy about what each arrow or manual says can't be removed by adding millions more to the landscape. The dead work or the signpost needs the living work of the traveler.

By the same token, none of the arrows, manuals, JPG images, digitized sentences or lines of code – or children's acts of pointing at the intriguing doggy or dragonfly – should be thought of as faulty or gappy because we haven't made them proof against every imaginable misunderstanding. They work perfectly well the way they are. To indulge in computer jargon, their flex is a "feature", not a "bug".

The point is general. The political theorist Michael Oakeshott once wrote that a cookbook "speaks only to those who know already the kind of thing to expect from it and consequently how to interpret it."[80] So, too, an orchestra conductor's beat is useful only to players capable of keeping the beat themselves, and her gestures only to those who can already argue among themselves over what it might mean in practice to treat a musical passage as (say) more like a flowing river than a narrow path through a dense pine forest. Rather than trying to transmit complete, preconceived patterns of action to an empty receptacle, the conductor makes an opening move that expects and demands a subsequent process of contingent social and physical interaction. A similar kind of friction is required for – and is not an obstacle to – political leadership.

What is sometimes forgotten is that this flex and friction is a feature of interaction with industrial machines as well. No machine, to quote Wittgenstein again, "contain[s] its own mode of operation".[81] Parts can bend, break off, melt. No software code is forever bug-free. What any machine actually does is in the end always an open question. It cannot act alone. Nor could it work if things were otherwise – either for capital or for the rest of us.

Yet, as Wittgenstein and Marx both observed, in some societies the machine tends to become a fantasy symbol of something it can never be: a magical thing that, in Wittgenstein's words, "already contains its possible movements in some mysterious way", in which the future is somehow "already present", determined and controlled by the past.[82]

In this fantasy, the flex and friction inherent in smart contracts are tacitly treated as "defects" that might – just might – someday be ironed out, or as "obstacles" on the way to an approximatable goal. The perfect hegemony of a dead past remains a horizon of aspiration.

Take, for example, the spats that roil the libertarian blockchain geek community whenever humans are revealed to have intervened to rescue some algorithm or other after it starts acting in unexpected ways.

One famous mishap occurred shortly after the biggest "automated corporation" in history, called "The DAO" – short for "decentralized autonomous organization" – was launched in April 2016 on a record-breaking, crowdfunded stake of over US$150 million. On 17 June, an anonymous hacker was able to siphon off a third of that sum, probably legally, just by carefully reading the "fine print" of the code that was supposed to govern the corporation's attempts to accumulate capital.

"I'm not even sure that this qualifies as a hack," wrote Cornell University computer scientist Emin Gun Sirir on the same day. "To label something as a hack or a bug or unwanted behavior, we need to have a specification of the wanted behavior."[83]

The mechanized corporation's code, of course, could never have been capable of that by itself. Its handful of human curators in the Ethereum Foundation had to step in to change *ad hoc* how the Ethereum code interpreted their blockchain.

In other words, the algorithms running The DAO were, as promised, “immutable,” “decentralized” and “autonomous” – until they weren't. In the words of technology observer Evgeny Morozov, the prophets of a “peer-to-peer” internet who had spent much of their time shouting “down with the gatekeepers!” turned out to have to shoulder the role of gatekeepers themselves.[84] The uproar among geeks dreaming of total mechanization[85] has yet to die down.

One thing did survive the debacle, however: the stubborn capitalist fantasy that, despite such experiences, some day machines really will eliminate the “bottleneck” of having to embed themselves in human history and society.

The same contradiction pops up in the habitual claims of Google and Facebook executives that the platforms and the data they assemble are nothing more than an online “mirror” of a separate world existing “offline” for which they are not responsible, reflecting trends but not creating them. In this vision, data-creating and -organizing algorithms and other machines are presented as capable of attaining a state in which they have broken free of living labour and have no need for further teaching, management, repair or interpretation, their future output predetermined by the past.

Everyone knows these assertions are false. Just as in the timber industry and the financial markets, efforts to systematize the monitoring of certain phenomena along machine lines – to treat all experience as past experience – are part of a process that involves changing those things (see BOX: The Regulation Reflex), which in turn alters the monitoring itself, and so on.

For example, social-networking data processed out of supposedly “offline” lives customize the ads and political feeds received “online”, which again alters “offline” lives. Conversely, the “offline” efforts of companies and individuals to make themselves more algorithm-readable force incessant changes to the search algorithms of firms like Google. Corporations and individuals then try to make themselves more visible to the new algorithms, and so on.[86] This is one form of the wear and tear – or obsolescence – that afflicts the dead labour of “iron” algorithms as much as it afflicts the dead labour of iron factory machines.

What's important to note, however, is that it doesn't *matter* how many times it is shown to be false that digital platforms merely hold up a “mirror to the world”, cutting out intermediaries and making knowledge available to the masses. The claim continues to be made, and will continue to be made.

It's persistent not just because of increasing pressures favouring the production of bullshit (that is, propositions deployed without much interest in whether they are true or false).[87] As will be explored further below, it endures, more importantly, because of its power as fantasy – a consensual ritual action occupying a load-bearing position in capitalist economics.

Wittgenstein Confronts Shannon

In practice, the “living dead” of crystallized labour that is idealized in smart-contract fantasies about eliminating intermediaries – which have the same structure as similar fantasies that sprang up during 19th-century industrialization – always takes specific historical forms.

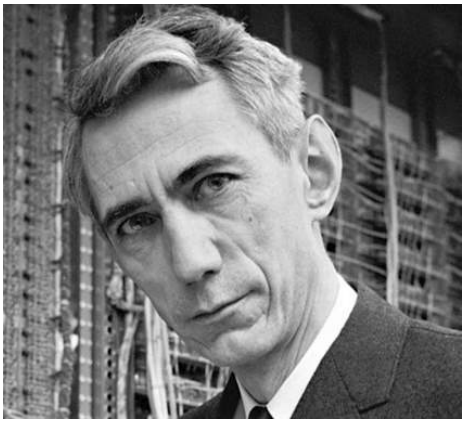
In the computer age, for example, there is the concrete, foundational story of Claude Shannon, a polymath electrical engineer, cryptographer and mathematician who worked at MIT and Bell Labs in the 1930s through the 1950s.

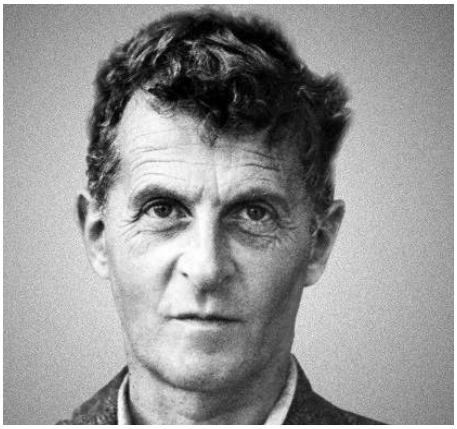
At around the same time Wittgenstein was writing, Shannon was helping get modern computing technology moving precisely by setting to one side the realities of meaning-making encapsulated in the child's finger, the signpost arrow, the cookbook, the orchestra conductor, the political leader and the actually-existing industrial machine.

Instead, he concentrated his attention on a reified, measurable "signal" or chunk of digitizable "information," and how to limit the losses it undergoes in being transmitted and processed.[88]

That kind of signal was nothing new in itself. It had been around long before the invention of the telegraph and Morse code in the early 19th century, when it had been decisively divided off from the fleshly bodies – human or animal – that had hitherto usually been needed to "carry" it.

But it is very much due to Shannon's thinking that we are able not only to think of pieces of human or nonhuman culture as fixed, set strings of ones and zeros but also to treat those ones and zeros as electronic circuits opening and closing at incomprehensible speeds.





Claude Shannon and Ludwig Wittgenstein:
emphasizing different aspects of information mechanization:.

Rather than living pieces of the "general intellect" itself, Shannon's "signals" (or "information") were quantifiable representations of bits snipped out of it and frozen for purposes of accelerated, secure electronic exchange. How much of that information could be packed into the electrical signal and transmitted between points A and B – or between a stylized "sender" and a stylized "receiver" – with the minimum of "noise" or interference? Under Shannon's influence, discussion of human communication became dominated more than ever before by the question of how to get a "signal" from point A to point B.

In a series of brilliant answers, Shannon did his bit to help create a new version of Marx's 19th-century "iron man confronting the man of flesh and blood". Within decades, digitized signals and the machines that produced and exchanged them were beginning to enter into familiar kinds of relationship with the

living processes of meaning-making. Untold octillions of new Shannonesque "signals" were constructed, analyzed, and circulated over novel networks.

As digital capitalism advanced, immensely aided by wartime and postwar systems analysis, it became easier to treat communication, like the rest of human activity, in terms of quantifiable "efficiency" and measurable "productivity." The isolation and black-boxing of the "signal" went hand in hand with the idea that intermediation between "senders" and "receivers" was the big problem in human understanding – a source of friction that, ideally, ought to be refined away or eliminated via machines so that nothing was "lost in translation" and everybody could communicate with everybody else as fast and accurately as possible.

What Shannon Said vs. What Happened in His Wake

Claude Shannon himself would have had no reason to deny that there is a lot more to interpretation than that. If you're a spy behind enemy lines, just because you have a secure, low-noise transmission channel to headquarters doesn't relieve you of the responsibility of going out and collecting your intelligence in the first place.

Similarly, when you a copy a PDF stored on your computer to a thousand email addresses, you are, in a manner of speaking, spreading "information" around much more efficiently than you used to be able to do. But the efficiency is possible only insofar as human beings perform living labour at both ends. At your end you work to put your PDF together. At the other end a million people work to make up their minds whether what they've received is the same thing that's on your computer. And then work to interpret the physical thing in front of them on their desk or computer screen. The "signals" whose transmission Shannon succeeded in lubricating through mechanization aren't able to interpret themselves.

Still less would Shannon himself have had any reason to claim – for example – that less corrupted, more efficient and secure circulation of "signals" about property would wipe out the need for property lawyers. Even though digitization now enables lawyers to send copies of title deeds to other lawyers a lot faster than used to be possible, to get their computers to carry out title searches instead of having their employees do it, and to speed up transfers of ownership and value via electronic currency transfers, it still leaves them a lot of work to do. Just as the advent of digital bank transfers still leaves politicians, government officials and central bankers a lot of work to do in creating and maintaining confidence in their currencies and credit ratings.

Indeed, the quantifiable Shannonian "signal" – what the philosopher Daniel Dennett refers to as "Shannon information" to distinguish it from everyday "semantic information"[89] – plays even less of a part in the specific work of property than it does in the work of interpretation generally.

A high-quality "signal" appearing in someone's office – in the form of an uncorrupted series of ones and zeros that can be mechanically transformed into an unblemished PDF copy of a title deed – is already in need of plenty of human work just to be understood. But think of the work that has to be added on top of that in order to transfer not just the title deed, but ownership itself.

You need the labour not only of lawyers but also of courts. You need the labour of police. You need the labour of fence-builders and guards. You need the labour of countless mummies, daddies and teachers instructing their children about the rights, duties and powers involved in the recognition of what is yours and mine. No amount of efficiently-transmitted, cryptographically-secure Shannon information

could provide that. Nor even a Star Trek transporter beam that transferred an actual physical property from one place to another.

What Shannon did do, however, was to help capital get moving on a project to construct an "information iron man" that wound up reproducing pretty much the same paradoxes (including the ecological contradictions and the ideological fantasies) as the industrial "iron men" of the 19th century. Today, heat engines have to power not only the attempts to mechanize rule-following exemplified by the assembly line, but also the attempts to mechanize rule-following exemplified in smart contracts. The productivity-oriented hypertrophy and capacity for high speeds that belong to both "iron" mechanisms – with their incessant, pounding or whispering repetitions – change both labour and environmental politics and the nature of the paid and unpaid work that has to be done.

It's true, for example, that smart contracts' attempted mechanization of trust can't eliminate the reality that the work of trust always "points" – like the child's finger – toward an as yet unknown future of reciprocal relationship-building that will tend to unfold only at a certain pace. But it's exactly for this reason that smart contracts confront human and nonhuman workers alike with the unending task of "fixing" the contradictions inherent in these reifications and amplified caricatures of the past and adapting them to an indeterminate future.

That job includes not only – for example – digitizing millions of human practices to the necessary standard and taking on the Sisyphean project of trying to code in advance all future states that might affect contract execution. It includes not only the waged and unwaged hard work so many of us are constantly engaged in to make ourselves more readable by algorithms, more visible to machines, and better able to act like machines ourselves. It also involves handling, absorbing or clearing away the mountains of fatigue and waste that result from the whole parodic automation effort.

In addition, while Shannon himself didn't have any need for rituals positing the existence of self-interpreting information, the institutions of the information capitalism that he helped create do.

One result has been an ideological edifice that Morozov calls, borrowing a term from architecture, "solutionism". This is the idea that, if knowledge is nothing but digitized packets of "content" (one up-to-date version of Shannon's "signal"), then progress must unquestionably be all about eliminating intermediaries getting in the way of its free exchange.[90] As Morozov paraphrases the notion, "as long as information is produced and processed efficiently, the legacy of the Enlightenment is believed to be in good hands."[91]

By the same logic, if property is nothing more than mechanizable title deeds, then why not just get on with the job of automating their enforcement and eliminating parasites like attorneys and states?

Viewed historically, this idea recapitulates in a new key capital's old, contradictory theme of always trying to go beyond the limits imposed on it by its need for living labour, raw materials, and other forms of what Marx called "use-value". It also echoes capital's habitual 19th- and 20th-century refrain about artisanal skills: "if what you want is cheaper and better cloth, paper, food, wheels or mobility, you have everything to gain and nothing to lose by capitalist mechanization."

As noted above, none of this has ever abolished capital's own need for living human and nonhuman activity in order to establish and re-establish bridges between encoded "dead" rules that are constantly built and built again out of past experience and an uncertain future. If the imagery of parasitism is to be used, let it be used more correctly. "Shannon information", however pathbreaking an innovation it was,

remains parasitic on "semantic information," just as smart contracts remain parasitic on what legal scholars call "semantic contracts". Neither has any meaningful existence away from its host.

What the "Information Iron Man" Does Do: Another Example

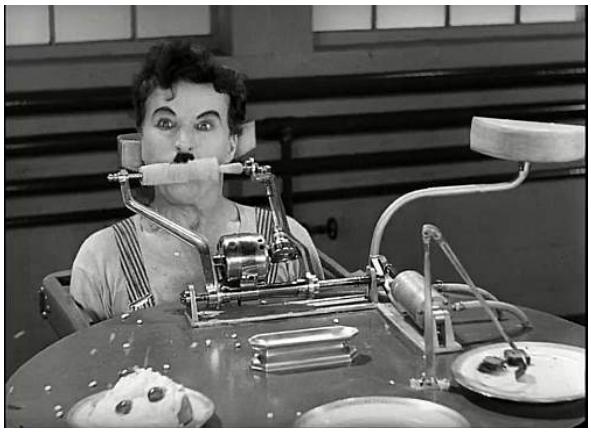
One area where the "iron man" of mechanized prediction does condition flesh-and-blood human decision-making in a new way is mass consumption.

Everybody who uses the internet has learned to expect it to tell you what you might want to buy even before you know it yourself. Retailers are now contemplating speeding up turnover still further by sending customers products before they have ordered them. Individualized automated forecasts of what they will accept have become so cheap and reliable that the economic risk of irate involuntary buyers returning the goods is perceived to be rapidly diminishing.

Big data and high processing speeds, in other words, are now capable of subordinating your choices as a shopper to algorithms that act on your tastes and needs faster and more accurately than you could yourself. The human work of shopping, already having been speeded up by micropackaging and self-checkout, gets transferred, as much as possible, to machines. The idea is to be able to go straight from producing stuff to shipping it without having to pass through shopping at all. If blockchain can connect the algorithms representing every web-connected person with those representing every web-connected thing, the churn could be even faster.

Is this kind of mechanized prediction a step toward Bill Gates's "frictionless capitalism"? Ask Charlie Chaplin's character in *Modern Times*, who had to cope with a company machine that tried to force-feed him his lunch.

Modern Times dramatizes one attempt to confront workers with automated predictions derived from their own historical actions that happens to have been made long before Gates was born. Ironically, it was only the "friction" that figures like Chaplin exemplified – in preserving themselves against the assault or hitting the road to join the "reserve army" of unemployed – that enabled capital itself to survive its own insistent efforts to mechanize their existence.



The smart contract as of 1936: Charlie Chaplin in Modern Times.

An equally emblematic but more up-to-date answer can be found in the remarkable 2010 novella *The Lifecycle of Software Objects* by the science-fiction writer Ted Chiang, whose day job with Microsoft gives him hands-on acquaintance with the issue. In Chiang's story, an artificial intelligence (AI) firm realizes that it just can't afford to pay for the slow years of freely-given human love and play that turn out to be indispensible for transforming its mechanical animals into beings that have enough independent judgement to sign contracts determining their fate.

Chiang's protagonist, Ana Alvarado, who has experience in training both animals and AIs, sums up for herself the Marxian/Wittgensteinian lesson: "experience is algorithmically incompressible."

"If you want to create the common sense that comes from twenty years of being in the world," Ana realizes, "you need to devote twenty years to the task."[92]

In the same vein, sociologist Judy Wacjman reproves intellectual prophets of "timeless time" such as Manuel Castells by noting that the "myriad ways" in which people deploy their ever-speedier machines in the lived world should never be described as the "annihilation" of time.[93] As Thomas Kuhn long ago observed of his famous "paradigms" of scientific practice, experience is "prior to, more binding, and more complete than any set of rules … that could be unequivocally abstracted from [it]."[94]

BOX: Time, Race and Bias

Being invisibly surrounded by millions of predictive algorithms mechanically executed and re-executed trillions of times per second necessitates new strategies for resisting those formidable forces of production known as racism, patriarchy and colonialism.

That might surprise and dishearten some of the idealists behind blockchain and AI. For them, such technologies ought to be a way of getting rid of bias and privilege, not augmenting them. But the actual politics is not difficult to grasp.

Imagine, for example, an algorithm that used big data, speedy processors, deep learning and meticulously-organized thermodynamic energy to suck up the entire history of jurisprudence: every judge's finding, every precedent, every piece of legal reasoning from hundreds of thousands of past cases. With the proper tweaks, such an "AlgoJudge" would be able to predict what accumulated legal wisdom would say about any particular current case.

AlgoJudge would be far more consistent in its opinions than human judges, whose vulnerabilities to mood, impulse, hunger, laziness, suggestion, personal bias, common failures of rationality and opportunities for corruption are well-documented.[95] In addition, it would work far better than machines programmed by judges themselves, just as Google Translate translates far better than translation systems programmed by linguists and "brute force" chess engines play chess far better than machines designed to follow rules thought up by grandmasters.

AlgoJudge could also conceivably advance understanding of many social issues. For example, if it were asked to give hypothetical judgements on ten thousand cases currently under way, it would be bound, statistically, to return decisions across a wide range of circumstances that we would recognize

as racist. Yet no one would be able to wave away its performance as being that of a random "bad apple" of legal thought.

That could be a big help in exploding the model of racism dominant across the white liberal middle classes of Europe and North America, according to which racism is a historical accident, rooted in a disjointed series of free, if morally-mistaken, personal choices taken in a shallow eternal present by a vast collection of unenlightened, biased individuals who need to be instructed in how to think better.[96] With a new vividness, AlgoJudge could demonstrate just how useless this understanding of racism is.

But now suppose that someone actually appointed AlgoJudge to the bench, on the theory that the courtroom should be a place where an impersonal, mathematical "rule of law", timely executed, decides cases, rather than the quirks, foibles, biases and fallibilities of individual human judges.

In such a role, AlgoJudge would be bound to entrench structural racism far more powerfully than any drunken human bigot. It would help render it a "natural" state of affairs for which no one was responsible.

To advocate using such an algorithm to improve jurisprudence would itself be racist. So would any attempt to "regulate" the algorithm, or its application, or make humans more machine-readable to adapt to it,[97] as if the problem were "computational" rather than social and historical. As Julia Powles, a professor of tech law and policy, argues, controversies over how to "solve" AI bias are in fact dangerous distractions from bigger, more pressing questions.[98]

The same point applies in the realm of blockchain. For instance, business pundits hail blockchain's potential to engender autonomous enterprises that require "little or no traditional management or hierarchy to generate customer value and owner wealth."[99] But what exactly is this "management" that is to be systemized through mechanization and where has it led us?

For decades, a brave band of thinkers has been engaged in critical historical studies of just that question. Harvard economist Stephen Marglin, for example, argued long ago in a paper called "What Do Bosses Do?" that the "capitalist organization of work came into existence not because of superior efficiency but in consequence of the rent-seeking activities of the capitalist."[100] More recently, historians David Roediger and Elizabeth Esch have explored the ways that slavery, settler colonialism and the "bloody history of race" are in the very DNA of the scientific business management that evolved in the 19th and 20th centuries, both in the US and abroad, where the claims to management expertise of US mining industry executives like Herbert Hoover "turned on their supposed knowledge of race and racial development and their experience with exploiting racial divisions among workers."[101] In the 21st century, the topic of management needs to be opened for more discussion, not closed by being treated merely as a "given" that just needs more automation to become ideally efficient.

Another example can be found in the business plan of a new firm called Nori,[102] which proposes to use blockchain to integrate millions of little individual actions into carbon markets, so that you could conceivably be paid automatically for every verifiable carbon-saving act, right down to not putting too much water in your kettle when making tea.

While advertised as politically empowering and involving, what this actually does is distract from necessary public discussions about production, value, mechanization, fossil fuels and a racist and patriarchalist extractivism.

Mistakenly construing the climate issue as a question of counting and managing carbon dioxide molecules, it plays into the characteristic, centuries-old fantasy of capital – discussed further below – that to improve efficiency is to move in the direction of an environmentally-benign perpetual-motion machine.

Calming the Nerds

Capital's insatiable need for more living labour and more and new kinds of commons to match digital machine expansion is one reason why its more far-sighted strategists can often be seen stepping in to try to cool things down when excited geeks start implying that their latest hi-tech brainstorm is going to be able to accumulate surplus all by itself.

Today, for example, numerous business pundits who would probably rather die than be caught validating Marx are not hesitating to point out, in effect, that the "dead labour" entombed in smart contracts and ritually sealed away on blockchains is going to be useless to capital unless animated by the touch of the "living labour" of actual, breathing (and no doubt greedy) lawyers, bureaucrats and other wayward human agents.

Thus the International Monetary Fund – ever concerned to help protect capitalists from their own worst instincts – warns that widespread use of smart contracts could "increase risks to financial stability by automatically propagating adverse events through the financial system, with self-reinforcing feedback loops (similar to the risks posed by automated high-speed trading)."[103]

The *Harvard Business Review*, for its part, frets that no matter how comprehensively blockchain is taken up, at some point the huge new quantities of digital records must be verified "offline" to be attached to actual physical things by armies of trusted and fallible human workers.[104]

Thus Nature 2.0 smart contracts, for example, will have no choice but to rely on the trust labour of those dread third parties when they need to check whether their subcontractors are providing the correct weather reports, drone surveillance readouts, or timber prices. By the same token, as trade union observers have pointed out, blockchain's claim to provide an automatic, instantly-available "truth" about the labour conditions prevailing at every link in the supply chain for every pair of shoes and every biodiversity credit is pure propaganda, a hi-tech rerun of previous "corporate social responsibility" scams. What goes for computer systems in general also goes for blockchain: garbage in, garbage out. From their side, meanwhile, supply chain consultants speak of the "blockchain paradox" that arises when an automated system for creating or obviating trust turns out to presuppose collaborations requiring trust to have already been established.[105]

Shrewd programmers chime in from the technical sidelines when they observe that smart contracts are faced, in effect, with the impossible challenge of somehow proving in advance "that a computer programme does not have bugs."[106] The more that smart contracts try to do so, paradoxically, the more unmanageable their commitment to securing large quantities of the very human labour that they aspire to make unnecessary.

Consider, for example, the example of the US's National Aerospace and Space Administration. NASA achieves its impressively low bug rate (maybe less than one per million lines of code) only at the cost of a great deal of checking and rechecking by fleshly human beings. Gerard estimates that Microsoft code, by contrast, averages 15 "obvious bugs" per 1000 lines, and Ethereum smart contracts perhaps 100 per 1000 lines.[107] The fantasy of encoding all possible future outcomes that could significantly affect a smart contract recalls the dreams of the formula-entranced top economists in the Bank of England in the heady days before the 2008 financial crash, who solemnly assured themselves that such a crisis could be expected to happen, on average, only once during every 6×10^{124} lives of the universe.[108] The reality is, as legal scholar Robert E. Scott emphasizes, that all contracts are always going to be "incomplete". "There are infinite states of the world and the capacities of contracting parties to condition their future performance on each possible state are finite."[109]

Ultimately, concludes programmer and entrepreneur Jimmy Song, smart contracts suffer from the same trust problem as normal contracts. By making a contract "smart", you don't necessarily do anything more than make it "more complex to write while still having to trust someone."[110] Small wonder that companies are already jumping into the blockchain market with what *Forbes* magazine openly identifies as "labour-intensive" security auditing protocols designed to debug Ethereum-hosted smart contracts.[111]

Lawyers Weigh In

Not surprisingly, many legal professionals are loudly – but not unreasonably – echoing these "geek critiques" of the fantasy of eliminating lawyers' living labour via blockchain.

Lawyers tend to be especially sensitive to the reality that contracts are about dealing with uncertainty about the future, not eliminating it. Some of their wisdom was summed up by the 19th-century French thinker Emile Durkheim, who stressed that not everything in a contract is contractual.[112] Contracts, like Wittgenstein's signposts or rules, presuppose an already-existing social order and can't be its foundation. They can be mechanized, sure, and *are* being mechanized, but that mechanization in turn demands new injections of living human work as well as presupposes forms of life in which people already have some idea of "how to go on."

Lawyers know, for example, that the parties to contracts often treat them "more like marriages than like one-night stands".[113] In such cases, contracts are like children's pointing fingers – they envisage a necessarily uncertain future relationship that will extend beyond the contract. They are not "frozen at the initial moment of commitment, but change as circumstances change," signifying a "commitment to cooperate"[114] whose specifics are not supposed to be spelled out once and for all at the present moment. Contracts depend on the very social behaviours that are inevitably sometimes going to subvert them.[115] In fact, as Cornell information scientist Karen E. C. Levy points out, they are sometimes *intended* to be unenforceable: preserving the option not to enforce can have cash value.[116] In general, one experienced business practitioner notes, "it is almost never sensible to write a contract that considers every possible future contingency."[117] Nor, indeed, could contracts ever come to do so.[118]

"There is no such thing as an immutable legal form," sums up the online *Crypto Law Review* in the course of a series of similar frontal assaults on the very idea of smart contracts. "Law is relational. Law is contextual. Law is a site of contestation." Those "gray areas" between what the law refers to as "code" – that confusing term also used by computer nerds – and "law in action" are not "bugs in the system; they *are* the system." Day-to-day law is about human lawyers "folding and bending" code to

advance clients' objectives, spur growth or innovation, bring constitutions up to date via interpretive work, and so forth.[119]

Real contracts, adds Angela Walch, a Texas law professor, unavoidably include standards of behavior, like "reasonable" or "in good faith."[120] You can try to encode such standards in software, for sure, but capital itself may not necessarily be happy with the results.

On the contrary, as legal scholar Jeffrey Sklaroff argues, the slipperiness of such notions as "commercial reasonableness" is actually pretty useful for capital. In volatile environments, keeping the definition of terms flexible until both parties know more about future developments can avoid "high drafting and renegotiation costs" and contribute to the good business relationships that keep opportunistic behaviour in check.[121] Unpaid human relationship work from the past that has inculcated a shared sense of how to go on may make for more efficiently-functioning agreements than elaborately nerdy, expensive efforts to code "future-proof", universally-legible mechanical contracts from scratch. In the long run, the transaction costs of conventional contracts can turn out to be less than those of smart contracts.

In short, to the degree that law will always be packed full to bursting with what software nerds call algorithms – the sheer mass of which has expanded especially dramatically under neoliberalism and is set to expand further with the advent of smart contracts – it also will continue to have to be saturated simultaneously with the recalcitrant, adaptive living labour of humans if it is to provide a framework that is "slow" and "anti-fragile" enough to help business deal with unanticipated future events.

Indeed, this reality has been deliberately exploited by some of the biggest parasitic growth industries of neoliberalism, which actively take advantage of – and sometimes deliberately cultivate – "overmechanization" in the law and the increased "ferality" that results. Regulatory codes governing banking, say, or trade, are now swelling to the point where only those corporations with the deepest pockets are capable of mustering the needed living legal labour to use the bloated rule sets to their advantage.[122] Other actors, including most state actors, are simply swamped.

It's not a new dynamic, of course. The characters in Charles Dickens' 19th-century novel *Bleak House* were well aware of it. But as a business model that has spread from law firms to the world's leading financial and industrial companies, it's a revealing mark of a later capitalism.

The Catch for Capital

In many ways, the story of smart contracts is a remake of Marx's old narrative describing how the "iron man" he spoke of is also a "vampire" hungry for more and more of the living activity of both humans and nonhumans. When reified rules multiply uncontrollably in the quest for surplus, the burden on the living labour needed to tie them to the future becomes overwhelming. The relevant contrast is with commons, whose pasts are not compelled to become either "dead" or "vampirish" in that sense.

The upshot is that the sources of the free lunches that capital is so skilled at organizing in order to ensure the economic performance of its trillions of machines, algorithms and machine-like techniques relentlessly get "maxed out"[123] one after another. Waste dumps get topped out. Women get fed up. Slaves die, flee or revolt. Soils are poisoned. Species go extinct. Entropy sets in. Colonies decolonize. "Yield honeymoons" go sour. Lucrative moments of "ecological release"[124] pass. Indigenous peoples, workers and environmentalists protest. What environmental economists confusedly call "natural

capital" gets depleted. The living labour of humans and others can't keep up with the need to keep "fixing" capital's growing body of machines.

In short, whatever methods happen to be used today for creating capitalist value, they're not going to function so well tomorrow. Fatigue always looms on the horizon, and the menaces of overcapitalization, overproduction and the lurch into crisis.

Accordingly, fresh frontiers to supply new kinds of free or cheap work from humans or nonhumans must continually be found and organized. Each element of capital – labour, commodities, resources, wages, rent, profit and so on – can never be more than an unstable, temporary, contradictory composite fusing commons and machine-like modes of organization, whose components continually have to be replaced. The labour process is always in flux. Innovation is a must. As Jason W. Moore puts it, capital doesn't *have* a frontier located on a moving boundary between "itself" and "something else"; rather, it *is* a frontier.[125]

One obvious example is China in the first decade or so of this century. In places like the Pearl River delta megalopolis, one of the largest waves of coal-fired mechanization of recent times – aimed at producing low-cost goods for export to North America and Europe, including, preeminently, computer components – went hand in hand with one of the largest waves of migration of fresh cheap labour from rural areas in the world historical record, as well as a massive global mining boom.

Predictably, the influx of inexpensive human work to tend the machines started to be "maxed out" within only a few years, when rising labour costs – including those manifested in public protests and the bad publicity resulting from worker suicides – precipitated a move by many companies to China's interior as well lower-wage countries like Viet Nam or Indonesia. Neither the short-lived, surplus "vitality" of this labour, nor the processes though which it started to be "maxed out", can be properly understood without some grasp of the multi-generational, more-than-human contexts in the Chinese hinterlands from which it had been partially separated – in the classic traditions of enclosure – in order to be utilized. As philosopher John Haugeland emphasizes, intelligence (including the common sense required to handle automation in society) "abides 'out' in the world".[126] For the new Chinese labour and the new Chinese capital alike, that more than merely human world is far older and larger than the Shenzhen factory floor.

So, too, one part of capital's job in using blockchain to accumulate value – via reduced transaction costs, faster circulation and turnover, new kinds of labour discipline, deeper market penetration or whatever – will be to manage the resulting additional fatigue, degradation and wearing out of the commons of the humans and nonhumans who continuously feed, fix and service the computer-driven algorithms. And ultimately, when the returns from such management no longer pay off, to start finding and organizing fresh frontiers of appropriation and exhaustion to follow and add to those that had formed part of the blockchain universe.

The Living Work of the More-than-Human

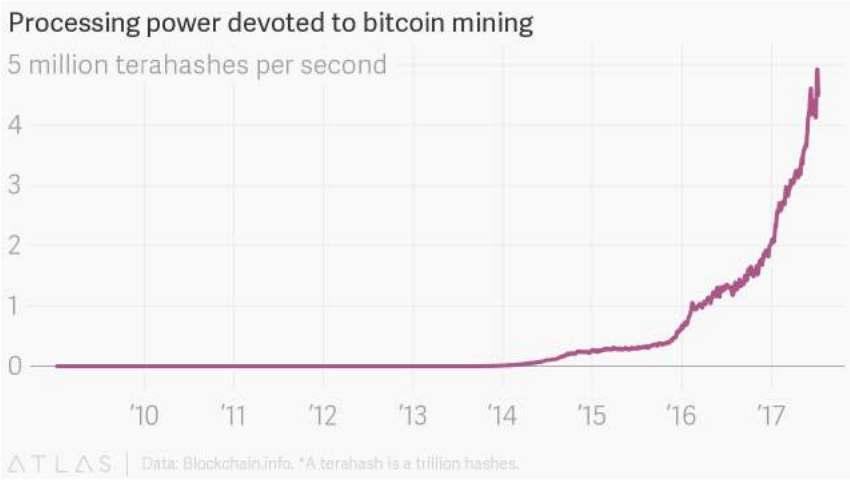
The immense amount of living nonhuman work used up by blockchain preoccupies even its most enthusiastic advocates. The energy cost of Ethereum's mechanized trust, for example (largely a matter of high-speed number-hashing), was reported in April 2019 as 35,000 watt-hours per transaction, compared to the non-blockchain Visa figure of 1.69 watt-hours.[127] The figure for Bitcoin is ten times that of Ethereum. The carbon emissions of blockchain as a whole are already on the order of those of a medium-sized country.

By 2025, the World Economic Forum speculates, assuming that 10 per cent of global GDP will be stored in blockchain, Bitcoin will have long since passed the point when it consumes more "power than the world does today."[128] According to a 2018 article in *Nature*, "Bitcoin emissions alone could push global warming above 2°C".[129] In other words, the costs of mechanizing interpretive work in the name of "efficiency" have to be externalized to the climate big-time to be viable in economic terms. Minimizing human trust work means maximizing electricity use. This is to say nothing of the mineral basis of digital technologies in the extraction of coltan, cassiterite, gold, cobalt, wolframite and a host of others, and the associated child and slave labour and devastation of soils, river basins and the rest.[130]

In short, the "brute force" computing behind blockchain – as well as Google Translate, image- and voice-recognition software, AI and so forth – is brute in a material, ecological sense. The attempt to replace trust with smart contracts and to boost the productivity of "recognition" and "interpretation" per human-hour of labour shifts an enormous burden to the environment few hints of which, following capitalist imperatives, can be allowed to appear on the balance sheets of private corporations. This pattern of subsidization is familiar from 19th- and 20th-century industries from textiles to automobiles. The only difference today is in what is being mechanized, and how.

It's revealing the extent to which this dynamic is implicated in the very design of cryptocurrencies. The mechanized "work" behind the scarcity value of Bitcoin, for instance, is explicitly modelled on the waste-proliferating operations that enable capital accumulation. And the seignorage paid to the energy-hungry cryptocurrency "miners" who operate warehouses full of computer processors certifying or verifying transactions is essentially a rent derived from the commodities whose circulation blockchain lubricates – and thus an indirect appropriation of some of the living human or nonhuman work that goes into making them.

The race to collect these rents at the least possible cost (which draws in nation-states as well as companies like Bitfury) has driven an exodus of computer processing power to locations where electricity is cheap and, preferably, the weather is cold (to save on costs of cooling the bespoke machines hashing all those numbers). China, Mongolia, Quebec, Iceland, the hydroelectric dam precincts of Washington state in the US, British Columbia, Utah, Wyoming – all loom large in the new tax farmers' quest for subsidies from nature. Naturally, that involves deals with local governments to maximize those subsidies, entailing familiar forms of local conflict.



Source: The Atlas, https://www.theatlas.com/.

Each of blockchain's ballyhooed "environmentalist" applications, without exception, partake of the same destructive dynamic. As usual, this dynamic is exacerbated by capital's customary insistence that environmental crisis stems not from capitalist value relations, but from the fact that there are not yet *enough* of them.

Hence, for capital, biodiversity crisis is to be addressed not by decommodification, but by accelerated commodification via a blockchain-based Earth Bank of Codes. Similarly, the vampire nature of agribusiness is to be addressed not through a renaissance of respect for food plants and animals – which are currently dominated by an "iron man" administering herbicides and growth hormones and draining soil fertility – but by transforming them further into "blockchain appliances" under the distant eyes of central managers and "green consumers". And so on. All of this is only hastening extraction and the degradation of land, water and air along multiple fronts.

The automated forest of "Nature 2.0", similarly, is built on a "Nature 1.0" which is a passive timber resource in the most conventional capitalist sense. The tract of land outside Berlin that blockchain visionaries are seeking to infuse with independence has no human inhabitants. Nor is it seen as what anthropologist Marisol de la Cadena would call, translating the Quechua word *tirakuna* as used in the Peruvian Andes, an "earth being".[131]

Far from being already animated, that is, Nature 1.0 becomes Nature 2.0 by being *given "*animation" by artificial intelligence and the "internet of things," which are what bring the "physical and natural assets, machines, physical and natural infrastructures to life, interacting with each other by sensing and responding to each other in real time."[132]

The rights of Nature 2.0, should it attain them, would then be those of a capitalist private property-owner. Its attempts to preserve itself would follow the same fantasmic, perpetual-motion logic of "sustainable timber production" that has already resulted in the degradation and exhaustion of so many lands and their inhabitants. Its survival and evolution as an autonomous agent plugged into capital's "internet of things" would be paradoxically dependent on the further parasitization and "maxing out" of whatever living energies were left over from its centuries-long history as commons, or from the history of other such places, or could be improvised out of their current predicaments.

In keeping with the logic of blockchain, the thrust of Nature 2.0 is not to try to understand or even study the precarious relations of trust and respect between the human and the more-than-human on which the livelihoods of so many millions have depended for so long.

Instead, Nature 2.0 deals with ruptures in these relations – which have seen peasants around the world losing their trust in the seasons at the same time they are pushed into losing respect for the water and land around them – by trying to *replace* trust and respect with stupendous volumes of energy-intensive cryptographic operations executed at more-than-lightning speeds by custom-made computer processors. Nature 2.0, the story goes, will survive not through trust and respect, but by freeing itself entirely, via mechanical means, from the need for them.

In the eyes of visionaries, for example, the ecological performance of agriculture can be considerably improved with wholesale blockchain mechanization. Public-private partnerships have already resulted in "hands-free hectares" in the UK that have been planted, tended and harvested without any human ever stepping foot in the fields.[133] A natural next step is to fuse such schemes with encrypted ledgers

that can make every detail of such operations visible to consumers at the other end of the commodity chain.

In this way, the complex relations of mutual dependence a peasant might have with, say, her cow and local forest fodder sources – which tend to unfold at a certain pace and involve a fair amount of improvisatory work – are seen as mechanizable across vast distances once those relations are refined into standardized connections among anonymous "peers" mediated by computerized encryption and decryption.

After all, if those old hands-on, personal relationships local bankers used to have with local clients taking out loans can be mechanized away in the cause of efficiency, why not those old peasant-cow-forest relations as well – particularly if the costs of the minerals, energy and cheap digital labour required can be kept so low?

In short, a blockchain-based "Nature 2.0" becomes autonomous only by accentuating the Cartesian dichotomy between itself – as "nature" – and a separate "society".

In the process, it also reinforces the diversionary "nature good, humans bad" mythology that capitalist states deploy and embody in "protected areas". The Nature 2.0 White Paper is perfectly explicit about this:

> "By appropriation of capitalist and cultural mechanisms, a piece of ground thus plays an active role in society, whilst at the same time avoiding direct influence by third parties, via removing the possibilities of economic interaction by them."[134]

Nature 2.0, in other words, is a "Nature 1.0" subject to all the complex processes of degradation of any capitalist nature, but with a new type of mechanization tacked on, complete with its own destructive dynamic. To be made into a Nature 2.0 that "just provides," via the "dead labour" crystallized in blockchain, Nature 1.0 has to be treated as dead to begin with. And once "reanimated", it will be pretty much like the rest of capital's vampires. It will need continually to go out in search of those who can still die so that it can "live".

Nature 2.0 thus carries forward one more step the capitalist readings of nature promoted by the United Nations, whose climate initiatives such as the UN Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change never mention trust or respect – or even use terms like "oil company" or "extraction".

The kind of "Nature 1.0" to be transformed into "Nature 2.0"

The Living Work of the Human

Behind the unpaid "digital labour" performed by everyone with a smartphone or laptop, as social theorist Christian Fuchs notes, is the "surveillance, blood, and sweat of superexploited [wage] labour in economic developing countries"[135] where computer equipment is made.

The computer age, Fuchs writes, has not overcome Taylorism (a debilitating early 20th-century attempt to reorganize workers' movements as completely as possible on a machine model that in many ways defeated itself). It may amount to an "even bloodier form" of it. Chinese Foxconn workers building Apple products and other information and communication technologies have faced "withholding of wages, forced and unpaid overtime, exposure to chemicals, harsh management, low wages, unsafe work environments, and lack of basic facilities." In 2010 alone, eighteen employees attempted suicide, fourteen of them succeeding. One Shenzen worker making computer parts for brands such as Apple and Dell notes that comrades' suicides are "simply to testify that we were ever alive at all, and that while we lived, we had only despair."[136]

Jack Linchuan Qiu, a communications professor at the Chinese University of Hong Kong, argues that the profile of the migrant factory girl or *dagongmei* on such sites overlaps with that of the "slave girl" of classical eras, with both patriarchy and "quasi-ethnic identifiers" deployed in the cause of information capital accumulation. A "newfangled regime of (servile) consumption" among information technology users, he suggests, is paired with a "marvelous regime of miraculous (slave) productivity".[137]

BOX: The Regulation Reflex

Conditioned by Hollywood and shallow journalism, public concern about the "internet of things" and the collection of masses of electronic data on individuals tends to zero in on the imagined menace of a new Big Brother.

The first question from columnists, academics and other observers is often who will have access to the new flood of information and what they will use it for. Before even asking what the new information machines *are* and how they work, they want to know how and whether they are to be regulated.

This hackneyed, hasty response is understandable, but misses deeper, more strategically-important issues.

By comparison, look at the way mainstream forestry techniques – which got their start in colonial-era Germany, India, Britain, Africa and the US – have transformed native forests into industrial plantations for the use of timber or paper and pulp industries.

As with information technology, the first step was to reorganize and rechannel knowledge about the forest into very specific varieties of digitized "Shannon information" that could be processed by algorithms or machines designed to help states and businesses maximize yield, cut costs, compare profitability between forests in far-flung regions, and so forth. Standardized measurements and maps of tree diameters, rates of growth and species composition had to be collected and collated in order that different forest stands could be properly valued and managed.

As political scientist James C. Scott has argued, this kind of surveillance was part of a process that tended to result in forests themselves being transformed into regimented plantations of selected species of trees – plantations that could then be even *more* easily monitored and mechanically harvested.[138]

In the case of the pulp industry, the drive to digitize is one with the drive toward planting genetically-identical clones across huge swathes of the landscape, ever-increasing use of agrochemicals, and so on. The nature of the ecological damage that follows – to soil fertility, biodiversity, disease resistance and all the rest – is well-documented. The resulting "maxing out" of the energies of nonhuman forest beings eventually forces capital itself to move on to fresher territories.

As this process unfolds, it's easy to imagine that the forest's own initial concerns might be about surveillance. The first worry of the mouse on the forest floor, for example, might be that irritating drone watching it scurry between food sources and den.

But it would seem almost beside the point to respond by calling for the institution of official "safeguards" for the murine right to privacy. The threat the forest mouse faces, after all, is not so much a nosy Big Brother as the flattening of both food sources and den in the interests of maximizing cellulose production.

Similarly, there may be nothing wrong in itself with calling for the regulation of the internet of things, the "blockchain of things", self-driving cars, cryptocurrencies or mass surveillance via social media and marketing technologies.

But such a response is not necessarily very practical in political terms – even if states were technically capable of grasping and dealing with what's going on, which they generally aren't.

The issues are not restricted to surveillance of our supposedly "offline" lives. They also include our consensual re-creation of those lives as an online/offline amalgam that *can* be readily surveilled, tapped for surplus and, in the form of attention, ultimately sold as a commodity in its own right. And the question of what happens when humans operating at the interface with interpretation programmes and other real or virtual machines lose modeling or other skills by adapting their behaviour to a machine model – something that some thoughtful artificial-intelligence and machine-learning nerds are themselves concerned about.

What needs to be confronted, then, are the debilitating consequences of voluntary subordination to another version of the obsessively past-oriented industrial "iron man" that Marx described.
State regulation has a poor record of even recognizing such issues, much less coping with them.

Structures of Fantasy

Comparing the contradictions of 19th-century and 21st-century capital means – among other things – seeking parallels between the fantasies that are integrated into both.

As Marx was only the first of many to emphasize, the fantasy structure of capital isn't something you can separate out at any point from its economic structure. The fantasies that help constitute blockchain and smart contracts today need to be seen as part of the same history as those that helped sustain 19th-century textile, steel or wood industries.

One common thread – in fact, probably the central fantasy winding through the whole history of industrial capital from the smart contract back through the Jacquard loom and before – is that of the perpetual motion machine.

Capable of sustaining itself independently forever, this benign, self-sustaining, automatic device tends to be pictured as something that releases value out of the "immaterial" ingenuity and self-discipline of capitalists – and not the unending exploitation of degradable, vulnerable, material (and also ingenious) human and nonhuman natures. Psychologically speaking, it belongs to the same family of myths as that of the European "self-made man" or the Cartesian self that has magically freed itself from dependence on the ancestors and the other-than-human.

Perpetual motion offers a way of screening out the unending, stupendous trauma inherent in capital – the enclosures and oil wars, the legalized violence against labour unions and fracked communities, the ongoing "insectageddon" threatening to decimate worldwide agriculture, the eviction of a million peasants recently mandated by the Indian Supreme Court, the melting ice making Inuit livelihoods impossible, the engulfing of the homes of 60,000 people in East Java by a mud volcano unleashed by a gas well, the news that self-reinforcing global warming could turn the Earth into a Venus where lead melts at ambient temperatures, and so on.

The perpetual motion machine, in other words, is the precise opposite of the vampire pictured in Marx's *Capital*, eternally hungry for the living tissue of *pachamama*, the soil, the commons, the

laboriously-respected sacred. No wonder that it's also tacitly invoked as the benign prospective outcome of the "shocks" therapeutically administered by neoliberal doctrine.

In political practice, the perpetual motion fantasy is closely entwined with the very Second Law of Thermodynamics that refutes it. The two mix together in something like the same way as the elements of the other "contradictory unities" of capital famously catalogued by David Harvey: the commodity (or resource) as a paradoxical blending of use-value and exchange value; labour as a perpetually problematic amalgam of creative human activity and measurable source of surplus; capital itself as a self-contadictory process combining production and realization, monopoly and competition, centralization and decentralization, freedom and domination; and so forth.[139]

Like these other composite, unstable entitites, the medley of perpetual motion fantasy and thermodynamic knowledge – so full of the kind of "metaphysical niceties" that Marx discovered in the commodity – is productive not in spite of but *because* of its incoherence. Just as industrial capital simultaneously needs and decimates commons (hence its fragile nature as a moving frontier), so, too, it must both "disbelieve" and, in another sense, "believe" in the perpetual-motion machine. At the same time it recruits, reconstructs, parasitizes and degrades more and more of the "living labour" of humans and nonhumans, it acts out rituals that say it is asymptotically approaching a state of nonparasitism.

Take the example of capitalist planners. Like everybody else, they know very well that there are no perpetual-motion machines. They know that machines cannot by themselves create the value they seek to accumulate. That's why they're always on the hunt for cheap workers and low-cost raw materials, setting up an Uber here or bribing forestry officials there. And why they need to spend so much time trying to figure out how to play off the need to separate people from their subsistence supplies against the need to maintain or create some commons as sources of free provisioning for labourers.[140]

Yet at the same time, capitalist planners are compelled to act "as if" perpetual motion machines existed – at least as a horizon of aspiration – and "as if" the commons that are being enclosed, worn out and substituted for did not. As the British social historian E. P. Thompson once wrote in another connection, the very idea of commons is problematic for capital.[141] While as an opinion or doctrine, the notion that there are perpetual motion machines can be swiftly discussed and dismissed, as an attitude implicated in the survival of capital in times of environmental crisis it can't be so easily uprooted.

How is "belief" joined together with "disbelief" in this way? For one thing, the fantasy of the perpetual motion machine is not "in the mind". It's not propaganda. It's not an "ideological extra" nor an optional bit of "superstructure". It's not a "ruling idea" dreamed up by elites and then foisted upon the masses. It's not a myth that can be debunked nor an illusion that can be dispelled. It's not a mask that can be ripped off, affording everyone an unbearable view of that fearsome vampire dentistry.

On the contrary, no one believes it. Everyone denies it. It's accepted everywhere that perpetual motion machines cannot be. Everybody makes fun of people who think that they can. Everyone displaces the notion into a "lost past" that precedes the formulation of the Second Law of Thermodynamics. There's no need to expose the myth, because it's already been exposed.

Where the fantasy can and needs to be sustained is in the world itself. While university economists, finance ministry functionaries and executives of green businesses ridicule the idea of perpetual motion machines, they spend every working day performing material rites that proceed as if they existed – rites that, damaging in themselves, also have long-lasting geophysical consequences.

The hinge between the two poles of the fantasy/science unity might be summarized in the formula of the fetish that the French psychoanalyst and student of colonialism Octave Mannoni discovered everywhere in 20th-century societies: "Of course I know very well that … but all the same …"[142]

For example: "Of course I know that perpetual-motion machines are impossible, but still, let's imagine that we are building one." Or: "Sure, I understand as well as you that carbon markets don't work, but will you please stop annoying me by pointing out that fact so I can get on with my job?"

For the fantasy/science unity to perform, the two dimensions, registers or genres divided by the "but" can't be telescoped into one. You can't say that because the fantasy contradicts the science, we must eliminate the fantasy, or vice versa. Both have to operate at the same time. Take away either and a void results.

Thus thermodynamic theory isn't an "obstacle" belief in which has to be suspended for the perpetual-motion fantasy to go into operation. Instead, to borrow the words of the Slovenian philosopher Slavoj Zizek, it's a "positive condition of the functioning of what it discloses in its gesture of 'demystification'."[143]

The case is similar to that of the bureaucrat who can't go strictly by the book without losing her ability to act as a bureaucrat, but has to pretend to all the same. Or the laborer "working to rule" as an unprosecutable way of going on strike, who won't make much money for her boss during that time but is "working", all the same. The smart contract may "fail" as science while it "succeeds" as fantasy, but you can't have the fantasy without the science, and vice versa, and meanwhile capital can do something new and interesting.

Indeed, what sociologist of science Harry Collins shows in his careful empirical studies of machine-human interactions is that one of the main varieties of living human labour required to bring the dead labour of machines to life is precisely fantasy, although he doesn't use that term.

As Collins observes, we not only constantly work to "repair" the deficiencies of machines. We also tend to go on to attribute this repair work, without realizing what we're doing, to the machine itself. Collins calls these varieties of living labour "Repair, Attribution and all That", or RAT for short.

For example, if in the 1990s you picked up a cheap pocket calculator and did the sum "7/11 X 11", you got the answer 6.9999996. But you didn't immediately send off an irate complaint to the manufacturer. Instead, you looked at the result and "saw" 7. Without making a big deal about it, you attributed the arithmetic that you were doing to the machine alone.

Similarly, if, in 2017, you were trying to find your way across London or some other irregularly laid-out city and you came to a crossing where the street jogs slightly before continuing along a slightly different line, your automated Google directions might have told you to "turn" on the cross street and continue for a couple of metres, and then "turn" back again to rejoin the street you had been walking on. Almost without thinking about it, you had to put in a bit of unacknowledged work to "correct" the machine's difficulty in handling open-ended concepts like *turn* and *just go straight through the intersection*.

Of course, any particular user-interface "bug" of this kind can be eliminated over time. These days, calculators no longer have the same problem with "7/11 X 11" that they used to. And Google directions may have already improved to the stage where they don't need exactly the same kind of interpretation

work they needed in London in 2017. The point, however, is that, with every rejiggered programme and improved machine, there will appear more and more unanticipated new areas where humans have to step in, often disavowing their own contributions.

Good computer interfaces are there not to get rid of this kind of RAT. They are there to hide it, by calling only on the most everyday human skills that everybody has. That tends to have the effect of making users unaware of how much unwaged living labour they're putting into their dealings with the machine (even if interface engineers themselves can't afford to forget the fact). The fantasy that the machine is "doing it itself" becomes critical to the whole operation.

In other words, it's part of the very business model of tapping these frontiers of zero-cost labour that the labour becomes almost invisible at the same time that the fetish of the self-running machine gets more entrenched. On a more macro-level, meanwhile, the conviction takes hold that decentralized contracting networks will all by themselves "magically eliminate middlemen and maximize liberty and individual choice".[144] The fantasy works both economically and politically in a way that facilitates the power shifts underway. Ideology, production and circulation are one.

As Zizek suggests, in the more streamlined versions of Mannoni's formula "of course I know very well that … but still …", the "but" can become an "and" or even a "because", and the clauses freely switched around. We have to build perpetual motion machines because we know they're impossible. We know that carbon markets don't work because we have to perpetuate them. In the information age, such dream-like logics may lie closer to the heart of capital's persistence than even Marx could have anticipated.

Environmentalism's Efficiency Dream

One example of how the perpetual-motion fantasy works in practice is the proposal to solve ecological crisis through "efficiency".

Many writers simply take it for granted that ecological action is identical to improvements in efficiency.[145] But the proposal doesn't make "rational" sense in terms of how capital actually works. While efficiency is almost always good for business because it cuts costs, it also encourages accelerated production of commodities, reinforces the need to sell as many of them as possible, and exacerbates the long-term call on aggregate resources.

Thus, as everybody is at least vaguely aware, the postwar age of great leaps in industrial efficiency in production and circulation of units of this or that commodity – for example, in cheaper and faster data search, energy provision and transport – has been accompanied by a historically-striking "great acceleration"[146] of ecological degradation. Computers, for example, have become perhaps one trillion times cheaper per unit computation in the last 70 years, while human labour has become from between two and ten times more expensive.[147] Light bulbs, airline engines, and thousands of other products have also become more and more efficient. Yet carbon emissions rise higher and higher and mining companies are pushed to go further and further in search of what they want.

It follows that, other things being equal, schedules for the reduction of emissions of such-and-such a molecule in such-and-such a production process are worse than useless if treated as the solution to crisis. No set of green managers could sensibly be charged with carrying out such schedules continually on a society-wide or all-product basis, because no such managers could ever circumvent the reality that the accumulation of value in capitalism requires constantly-renewed fresh supplies of living work from

humans and nonhumans. No one could ever be in a position to empower such managers, much less grant them political omnipotence. They would be fired if they ever even tried to set capitalist production as a whole on a path asymptotically approaching zero waste.

Despite this awareness, however, most environmentalism – at international, national and local levels alike – continues to organize its practice around the abstract notion that greater parsimony in use of resources per unit produced will progressively reduce capital's need for the living work of nature. Every individual emission reduction or micro-saving is reflexively understood and promoted – through policy and everyday practice – as being in itself a "step in the right direction". The political programme that follows depicts itself as consisting of the management of resources along an asymptote that approaches – even if it admittedly never quite reaches – perpetual motion.

Fantastical political programmes of this kind have a solid cash value: they effectively preclude others. If living work doesn't really need to be "inside" value at all, what need could there possibly be for a politics that eschews the fanciful concept of "resource management" and instead confronts directly the issue of exhaustion or "maxing out" of the capacity for such work?

The Fantasy of "Goldilocks" Prices and the Circular Economy

Another ritual tacitly grounded in the perpetual motion machine is the popular environmentalist proposal to engineer "Goldilocks" prices for resources. These are prices that are "just right", neither too high to shut down accumulation of capital nor too low to enforce adequate environmental care. With the right taxes, we are told, or the right market prices for raw materials or environmental services, ecological crisis can be averted forever.

Again, the proposal has no "rational" basis. Common sense tells us that industrial capital always needs to push down prices of raw materials and labour relative to those of higher-entropy manufactured goods. Attempts to raise the former to the hypothetical levels that would preclude ecological crisis are consistently – and rationally – forbidden by states, by violence if necessary. Prices must be finite and they must be organized in patterns that enable the "tradeoffs" needed to sustain profit. "Externalizing costs" is what good business is all about.

Try, however, reminding policymakers of that in a public forum. Not only will they change the subject. Calling to their aid the perpetual motion fantasy and the rhetoric of "steps in the right direction", they will most likely try to prevent anyone else from talking about it either.

One reason it's so easy to do so is that the institutions of orthodox economics themselves reproduce the perpetual motion image, decorating it with various methodological curlicues and numerological excursions involving "market equilibrium", "equal exchange", "self-sustaining growth", "takeoff", national and global "market mechanisms" carefully set in motion and tended by the state, and the like. Recent variations such as "sustainable development", "renewable resources", "circular economy" and "environmental economics" don't interrupt the fantasy, but are an apotheosis of it.

So while the scientific responsibility to "disbelieve" in the perpetual motion machine continues to be formally honoured, shimmering icons of the device rematerialize every day in the theatres and prayer rooms of parliaments, bureaucracies, think tanks, university economics departments and the United Nations. As Zizek might put it, you don't have to *believe* in perpetual-motion stories in order to work in such places. You don't need to "repress" your scientific knowledge, or feel guilt or trauma over any

imagined dishonesty. The UN and the other institutions do all the "believing" for you. All you need to do is act *as if* you believed.[148]

In fact, the very disavowals you put between yourself and the belief in perpetual-motion machines are integral to the institutional rites. The perpetual-motion ideology requires, as its "paradoxical supplement", a "superior knowledge" that appears to discard it. It can do its work only because it is known not to be true. Part of the fantasy is the notion that it is not *you* who living your life as if perpetual motion machines were real.

Take a mildly dissident yet fundamentally orthodox economist like Herman Daly. Daly understands better than most the impossibility of a perpetual motion machine. In fact, he's spent much of his career gamely battling his colleagues' determination to pay as little attention as possible to the Second Law of Thermodynamics.

Yet he's spent the same decades repeatedly burnishing his own graven images of something very like a perpetual-motion machine. Ignoring the nature of capital as a mobile frontier and the role of private property within it, he talks about a "steady-state economy." He draws diagrams with arrows cycling round and round depicting how capital could approach "sustainability" if it could only just understand that it has reached the purported planetary "boundaries" of the Cartesian "environment" or "stock of assets" that supposedly surrounds, contains, yet somehow remains distinct from it.

Such images can be seen as "embodied disavowals"[149] of the same Second Law that Daly embraces – disavowals that nevertheless allow him to attribute any disrespect for it to a Big Other or an Unenlightened Past. Keeping the image of a perpetual motion machine shiny, via a lot of academic labour, can perhaps be seen as an environmental economist's response to the trauma of those otherwise intolerable insectageddons and mud flows, the exhaustion of all that living work of human and extrahuman nature.

It's like the joke Zizek tells about the renowned nuclear physicist Niels Bohr. Surprised at seeing a horseshoe above the door of Bohr's country house, a visitor remarks that he doesn't believe that horseshoes keep evil spirits away. Bohr snaps back: "Neither do I. I have it there because I was told that it works even when one doesn't believe in it."

Activists on the left shouldn't assume they have unusual skills for avoiding this predicament. None other than the *New Left Review* recently found itself cheering on Daly's anti-Marxian notions. Left intellectuals are also strikingly susceptible to a fantasmic image in which economic growth or "globalization" inexorably eliminates remaining "pockets" of anticapitalist resistance as commons are progressively enclosed one by one and everyone becomes part of a perpetual-motion machine.

Some leftists can even be spotted bending the knee in front of familiar murals depicting how greater efficiency, growing digitization and juster taxes and other prices will someday issue in a sustainable capitalism. Or succumbing to the temptation to formulate "alternatives" for those nonexistent omnipotent green managers. Or falling into the idea that an "automated communism" will obviate ecological crisis while delivering hypercars and environmentally-responsible penthouse suites to the masses.[150]

Perpetual Motion in Cyberspace

One thing that makes the perpetual motion fantasy increasingly visible in the historical record is the way it's being replicated and augmented today in the development of blockchain and smart contracts.

Time was when manual workers were regularly threatened with the perpetual-motion bogeyman of the factory that runs itself. Today, capital has a new bogeyman on call – a machine that purportedly gets rid of the need not only for manual and clerical labour, but also for more encompassing kinds of work like interpretation, recognition, identification, care and the building of trust and respect.

As this essay has suggested, this bogeyman is in some ways bigger and badder than your conventional mechanization bogeyman. He's here to take away not only your job as an administrator, factory worker, customer relations officer or truck driver, but also the jobs of a lot of other people who work behind the scenes to keep the institutions of property, contract, finance, research, welfare, law and the market itself going.

But there's more going on here than just a few extra rhetorical threats. What really galvanizes today's blockchain nerds, and not a few blockchain capitalists, is not just *automation*, but also – in a sense that goes beyond even the most fevered imaginations of 19th-century capitalist ideologues – *autonomy*. As the Wall Street writers William Casey and Paul Vigna put it, it's not just about reorganizing workers' lives, but about changing the "very nature of social organization."

Behind the various individual functions being discovered or invented for AI, blockchain and the internet of things – self-driving cars, machine-to-machine communication, human-free agriculture, automated finance and all the rest – lies a higher ambition. This is to realize, at long last, capital's eternal dream of grounding the institutions of private property, value and the market entirely in the dead, nonhuman "nature" that it went to work building 500 years ago.

Capital's geeks have intermittently been imagining ways of sidestepping the Second Law of Thermodynamics since James Clerk Maxwell thought up his famous Demon back in 1867. But what's being formulated now is a whole different kind of perpetual motion fantasy.

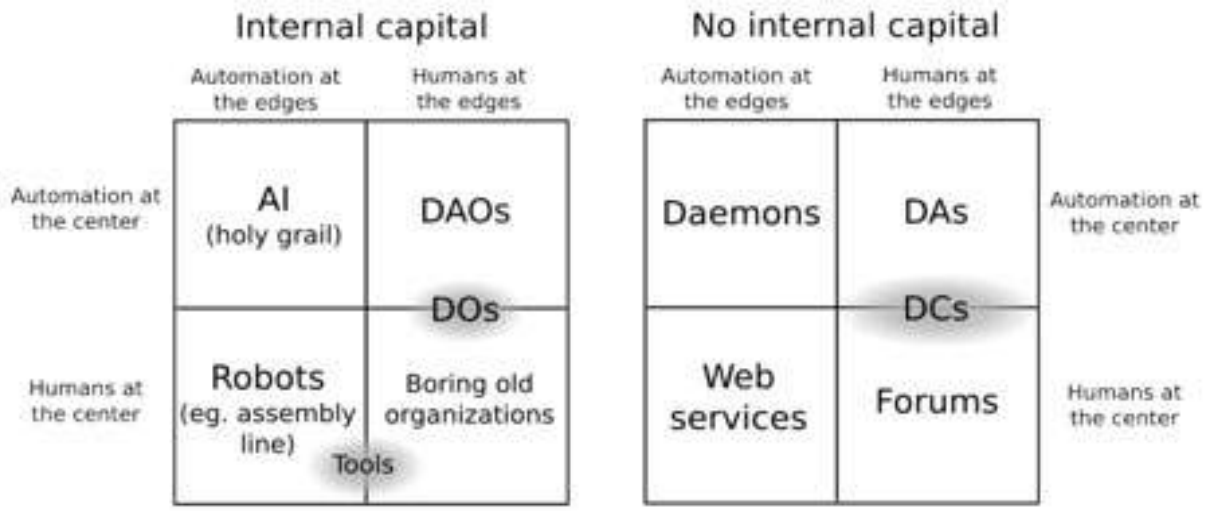
This isn't the crude 18th-century fantasy in which crankshafts rotate forever on a single pulse of energy. Nor the equally-crude 21st-century fantasy in which the waste from capitalist production becomes its fuel. It's a fantasy in which the whole social and natural infrastructure of capital becomes as human-free and self-sustaining as the imaginary, fully-automated individual factory of the past was supposed to be.

One fascinating exhibit is a table (below) drawn up at age 19 by the now 25-year-old genius who founded the blockchain platform Ethereum, which supports the Nature 2.0 project.[151]

Vitalik Buterin – whose net worth is already estimated to approach US$100 million – is not just out to automate this or that socionatural relationship using blockchain and smart contracts. He also hopes to turn around and build up independently-acting, rights-bearing entities out of these already-mechanized relationships.

That is, out of the very process aimed at eliminating this or that category of agent (greedy lawyers, for instance), he expects to be able to create agents of a different kind. These agents go beyond computer viruses, self-replicating cloud services, simple smart contracts, even Decentralized Autonomous

Organizations (DAOs), culminating eventually in “full artificial intelligence” as an owner – perhaps *the* owner – of capital.



Fantasy in the early research programme of Vitalik Buterin of Ethereum: the “holy grail” of capital accumulation without human labour. AI stands for Artificial Intelligence, DOs for Decentralized Organizations, DAOs for Decentralized Autonomous Organizations run via smart contracts on blockchain, DCs for Decentralized Communities, DAs for Decentralized Agents. Daemons are computer programmes running in the background without being under the direct control of users, including programmes prepared to respond in particular ways to various possible future events.

Buterin’s table differentiates applications or organizations that have “internal capital” from those that don’t. “Internal capital” he defines as “some kind of internal property that is valuable in some way” and that can be used by the entity in question “as a mechanism for rewarding certain activities”. That is, as something the apps or organizations own and can use to pay wages or fees.

Examples of organizations without this internal capital include conventional forums where humans meet and talk with other humans, but also somewhat more mechanized “web services” that deploy extra automation around the “edges”. Also in this category are “decentralized applications” (DAs) like BitTorrent and “decentralized communities” (DCs), such as those loosely clustering around various internet platforms. Rounding out the roster of apps without their own capital are “daemons”, or choice-making computer programmes not under the control of human users. (Although one of the most ambitiously-conceived daemons, in Daniel Suarez’s 2009 science-fiction novel *Daemon*,[152] seems to have independent control over an awful lot of labourers and assorted hardware, including advanced war weapons.)

On the left hand of Buterin’s table are organizations or apps that do possess “internal capital”. Here, what appears to be standard 20th-century-style industrial capital is characterized as involving “humans at the centre, automation at the edges.” With DAOs, automation shifts to the centre, leaving humans at the edges.

But what Buterin revealingly labels the "holy grail" – the final step of full AI – is an entirely human-free capital, in which automation reaches all the way from the "centre" to the "edges". This is the ideal endpoint of all those self-executing contracts, those means of production that own themselves, those repeated efforts toward a more mechanized legal system. It's a deep representation of the fantasy – ubiquitous among anarcho-capitalist nerds and financial journalists alike – that blockchain can serve the environment by integrating every last bit of atmosphere, water, soil and forest into a closer, more mechanized, more "efficient" relation with capital approaching the status of a circular economy.

Entwined in the Ethereum agenda, then, is none other than the old perpetual motion machine that creates capitalist value unburdened by any need for living labour. A device useful for frightening labour, but without any need to crack commons in order to release their surplus-creating energies. A machine that can wipe out class relations by simultaneously accumulating capital and providing for living beings without exploiting and exhausting them. A figure of appealing, fertile contradictions that "believes for you", structuring your "effective relationship to reality"[153] without your having (*per impossibile*) to believe *in* it for a moment. A testament to the staying power of a fantasy that goes on regenerating itself a full century and a half after the formulation of the Second Law of Thermodynamics.

In line with classic patterns of fetishism, Buterin's "holy grail" is unserious and deadly serious at the same time: alive in 9-to-5 work schedules in countless IT corporate cubicles as well as in conclaves of elite programmers and capitalist research programmes. Inevitably, it comes to haunt the actions of workers and commoners too. Labour itself comes to believe that it can be eliminated by machines. Or that the best it can do is try to imitate them as closely as possible. Or that state regulation constitutes its last hope.

Conclusion

Attempts during the past decade toward the wholesale automation of interpretation, translation, recognition, identification, care and the building of trust and respect bear comparison with the mechanization efforts of the 19th century. The different objects of mechanization and the different kinds of engines involved – with 20th-century Turing machines now supplementing and being powered by 19th-century heat engines[154] – should not distract from the fact that the contradictory drive to "accumulate, accumulate" characterizes both phenomena.

Nor should the different types of what Marx called "living labour" that are involved in the two waves of automation obscure the fact that living labour continues to need to be appended to the "dead" labour embodied in machines for capital accumulation to take place. Nor the fact that the ecological consequences – in the shape of the exhaustion or "maxing out" of both human and more-than-human activity, as well as the incessant organization of new frontiers – are parallel, with each of the two interlinked mechanization waves reinforcing the other.

This paper has suggested that attempts to explore these parallels – with an eye to resisting the unrelenting hype surrounding the supposedly new "knowledge economy" – may need to go hand in hand with an effort to update Marx's old distinction between living and dead labour.

This distinction – central to the labour theory of value, to the hypothesis regarding the tendency of the rate of profit to fall, to the theory of capital itself – has sometimes seemed a bit hazy. The cloud of nouns that has surrounded the concept of living labour – "vital energy", "will", "bodily subjectivity", "form-giving fire", "self-negating capacity", "openness of activity", "irreducible creativity",

“wholeness”, “the capacity to refuse or resist”, the “blood” on which the vampire of dead labour feeds to produce surplus – is suggestive, but stubbornly metaphorical and sometimes archaic-sounding, even if the lack of fixed boundaries is arguably part of makes Marx's conceptions of capital so powerful and flexible.

What if, however, instead of trying to impose a summary clarity on the concept, we simply try to enrich it to keep up with the times? One way to do so, this paper has argued, is to recruit the thinking of the later Wittgenstein, who formulated his last arguments when real-life Turing machines were just starting to appear.

Wittgenstein argued that a rule is useless in the absence of those who know when it applies and when it can be broken; and similarly for any second rule anyone might formulate about how to interpret the first rule; and so on. The “information economy” may be a useful stimulus to look at this “rule-following paradox” as being one with the “contradiction” between living labour and both of the productivity-boosting forms of dead labour that dominate the current era: the heat engine and the Turing machine.

Both machine-types “embody” certain past repertoires of human action in ways formulable in rules. Both enable the repetition of behaviours associated with those “dead” rules at very high speeds in ways that discipline and oppress both human and nonhuman activity. But the same detachment of “embodied” or “dead” algorithms from their former socionatural contexts that enables surges in the output of surplus also makes them “feral” in a way that ultimately renders them useless to capital unless fresh troops of living labour are constantly enlisted to provide “repairs”, “cleanup”, “updates”, “interfaces”, “waste management”, “circuit-breakers” and “reinterpretations”.

One virtue of this account is that, while not questioning Marx’s account of how 19th-century industrial machinery, as dead labour, came to “dominate” living labour, it casts that story as a special case of a more general dynamic that now also involves computers, artificial intelligence, machine learning, blockchain, and a capitalistic hunger for living labour that, increasingly evidently, extends to the other-than-human.

1 For a powerpoint companion piece to this essay, see “The Ecology of Trust Mechanization,” FLACSO, Quito, 2019, http://www.thecornerhouse.org.uk/resource/ecology-trust-mechanization and the video recording at https://www.youtube.com/watch?v=CB4HjNAsRxY.

2 Zizek, *First as Tragedy, Then as Farce*, London: Verso, 2009, p. 6.

3 Jennifer Langston, “A Q & A with Pedro Domingos: Author of *The Master Algorithm*,” University of Washington News, 17 September 17 2015, https://www.washington.edu/news/2015/09/17/a-q-a-with-pedro-domingos-author-of-the-master-algorithm/.

4 Juan Carlos Castilla-Rubio, “Nature-Inspired Design: How the Amazon can Help us Solve Humanity's Greatest Challenges,” World Economic Forum, 25 June 2017, https://www.weforum.org/agenda/2017/06/bio-inspired-design-amazon-technology/ 25 June 2017; “Sequencing the World,” *The Economist*, 23 January 2018; https://www.weforum.org/agenda/2017/06/bio-inspired-design-amazon-technology/.

5 Don and Alex Tapscott, *Blockchain Revolution: How the Technology behind Bitcoin is Changing Money, Business and the World*, New York: Penguin, 2016, pp. 152, 170. See also CNN Business, “How 5G Will Change the Future of Farming,” 2 April 2019, https://edition.cnn.com/2019/04/01/business/5g-farming/index.html; Juan Carlos Castilla-Rubio, Simon Zadek and Nick Robins, *Fintech and Sustainable Development: Assessing the Implications*, Geneva: United Nations Environment Programme, 2016, p. 33.

6 The Plantoid Project website, http://okhaos.com/plantoids; Primavera de Filippi and Aaron Wright, “The Blockchain of Things,” *Slate*, 19 June 2018, https://slate.com/technology/2018/06/blockchain-is-likely-to-advance-the-internet-of-things-and-robot-rights.html; Primavera de Filippi, “Plantoid and DAOS: Blockchain-Based Life Forms,” *YouTube*, https://www.youtube.com/watch?v=5gMbhCgHGjY, Youtube; Kat Mustatea, “Meet Plantoid: Blockchain Art With A Life Of Its Own”, *Forbes*, 31 January 2018.

7 Paul Seidler, Paul Kolling and Max Hampshire, “terra0: Can an Augmented Forest Own and Utilise itself?” Berlin University of the Arts, 2016, https://terra0.org/assets/pdf/terra0_white_paper_2016.pdf. See also Sofie Czilwik, “Dieser Blockchain-Wald forstet sich selbst auf!”, *Wired*, 29 September 2017, https://www.wired.de/collection/tech/forstwirtschaft-blockchain-wald-terra0-0.

8 “Julz”, “Bitcoin the Enabler: Truly Autonomous Software Agents Roaming the Net,” 6 December 2011, https://bitcointalk.org/index.php?topic=53855.0.

9 Amartya K. Sen, “Rational Fools: A Critique of the Behavioral Foundations of Economic Theory,” *Philosophy and Public Affairs* 6, 4, 1977, pp. 317-344.

10 Paul Seidler, Paul Kolling and Max Hampshire, “terra0: Can an Augmented Forest Own and Utilise itself?” Berlin University of the Arts, 2016, https://terra0.org/assets/pdf/terra0_white_paper_2016.pdf, p. 3.

11 Trent McConaghy, “Nature 2.0: The Cradle of Civilization Gets an Upgrade,” https://blog.oceanprotocol.com/nature-2-0-27bdf8238071. See also https://terra0.org/.

12 H. M. Collins, *Artificial Experts: Social Knowledge and Intelligent Machines*, Cambridge, MA: MIT Press, 1990, p. 10.

13 Paul Seidler, Paul Kolling and Max Hampshire, “terra0: Can an Augmented Forest Own and Utilise itself?” Berlin University of the Arts, 2016, https://terra0.org/assets/pdf/terra0_white_paper_2016.pdf.

14 Trent McConaghy, “Nature 2.0: The Cradle of Civilization Gets an Upgrade,” https://blog.oceanprotocol.com/nature-2-0-27bdf8238071.

15 Paul Seidler, Paul Kolling and Max Hampshire, “terra0: Can an Augmented Forest Own and Utilise itself?” Berlin University of the Arts, 2016, https://terra0.org/assets/pdf/terra0_white_paper_2016.pdf, p. 1.

16 James Essinger, *Jacquard's Web: How a Hand-Loom Led to the Birth of the Information Age*, Oxford: Oxford University Press, 2004, p. 223.

17 Henning Diedrich, *Ethereum: Blockchains, Digital Assets, Smart Contracts, Decentralized Autonomous Organizations*, Wroclaw: Wildfire Publishing, 2016, p. 3.

18 Tapscott, Don. “How the Blockchain is Changing Money and Business,” *YouTube,* 16 September 2016, https://www.youtube.com/watch?v=Pl8OlkkwRpc&t=2s; Aaron Wright and Primavera De Filippi, “Decentralized Blockchain Technology and the Rise of *Lex Cryptographia*, unpublshhed paper, 2015, https://papers.ssrn.com/sol3/papers.cfm?abstractid=2580664.

19 Vinay Gupta, “The Promise of Blockchain Is a World Without Middlemen,” Harvard Business Review, March 2017, https://hbr.org/2017/03/the-promise-of-blockchain-is-a-world-without-middlemen.

20 Don and Alex Tapscott, *Blockchain Revolution: How the Technology behind Bitcoin is Changing Money, Business and the World*, New York: Penguin, 2016, p. 140.

21 Op. cit., pp. 139-142.

22 Henning Diedrich, *Ethereum: Blockchains, Digital Assets, Smart Contracts, Decentralized Autonomous Organizations*, Wroclaw: Wildfire Publishing, 2016, p. 7.

23 Peter Kreidte, Hans Medick et al., *Industrialization before Industrialization*, Cambridge: Cambridge University Press, 1981; Paul Glennie and Nigel Thrift, *Shaping the Day: A History of Timekeeping in England and Wales 1300– 1800,* Oxford: Oxford University Press, 2011.

24 See https://infinite-earth.com/carbon-credits-infiniteearth-redd/; see also Veridium website, https://www.veridium.io/.
25 H. M. Collins, *Changing Order: Replication and Induction in Scientific Practice*, Chicago: University of Chicago Press, 1985.
26 Karl Marx, *Capital*, vols. 1-3; *Theories of Surplus Value*; *Grundrisse*.
27 James Essinger, *Jacquard's Web: How a Hand-Loom Led to the Birth of the Information Age*, Oxford: Oxford University Press, 2004, p. 38.
28 David Noble, *Forces of Production: A Social History of Industrial Automation*, Oxford: Oxford University Press, 1986.
29 H. M. Collins, *Artificial Experts: Social Knowledge and Intelligent Machines*, Cambridge, MA: MIT Press, 1990.
30 Don Tapscott, "Understand Blockchain in under 7 Minutes," Lloyds Bank, *YouTube*, 22 March 2018, https://www.youtube.com/watch?v=isuAPyuqS7Y.
31 Nick Szabo, "Trusted Third Parties Are Security Holes," Satoshi Nakamoto Institute, 2001, https://nakamotoinstitute.org/trusted-third-parties/; Melanie Swan, *Blockchain: Blueprint for a New Economy,* Sebastopol, CA: O'Reilly Media, 2015; Jeremy M. Sklaroff, "Smart Contracts and the Cost of Inflexibility," Sklaroff, Jeremy M., "Smart Contracts and the Cost of Inflexibility," University of Pennsylvania Law School *Prize Winning Papers*. 9, 2018, https://scholarship.law.upenn.edu/prize_papers/9.
32 Nick Szabo (@nickszabo4), *Twitter*, 3 September 2015, https://twitter.com/NickSzabo4/status/639663431918850048.
33 Nicky Woolf, "Everything You Need to Know About Blockchain But Were Too Embarrassed to Ask," *Medium*, 21 December 2017, https://medium.com/s/welcome-to-blockchain/everything-you-need-to-know-about-blockchain-but-were-too-embarrassed-to-ask-b3cee3e918f8.
34 Andreas M. Antonopoulos, *Mastering Bitcoin: Programming the Open Blockchain,* Sebastopol, CA: O'Reilly Media, 2017. See also graph at https://cdn.howmuch.net/content/images/ex3-5-1.jpg?link=mktw.
35 David Gerard, *Attack of the 50-Foot Blockchain: Bitcoin, Blockchain, Ethereum and Smart Contracts*, David Gerard, 2017.
36 Shoshana Zuboff, "Surveillance Capitalism and the Challenge of Collective Action," *New Labour Forum,* City University of New York, https://newlaborforum.cuny.edu/2019/01/22/surveillance-capitalism/.
37 David Shrier, Deven Sharma and Alex Pentland, *Blockchain and Financial Services: The Fifth Horizon of Networked Innovation*, Massachusetts Institute of Technology, MIT Connection Science, Cambridge, MA, 2016, https://www.getsmarter.com/blog/wp.../mit_blockchain_and_fin_services_report.pdf, p. 7.
38 Andrew Schmahl, Sanjaya Mohottala et al., "Resolving the Blockchain Paradox in Transportation and Logistics," Boston Consulting Group, 29 January 2019, https://www.bcg.com/en-gb/publications/2019/resolving-blockchain-paradox-transportation-logistics.aspx.
39 "New Digital Supply Chains are Powered by Artificial Intelligence and Predictive Analytics," *Supply Chain 24/7*, 17 December 2018, https://247customsbroker.com/index.php/2018/12/18/new-digital-supply-chains-are-powered-by-artificial-intelligence-and-predictive-analytics/.
40 Andrew Ure, *The Philosophy of Manufactures,* London, Charles Knight, 1835.
41 Lauren Henry Scholz, "Algorithmic Contracts," *Stanford Technology Law Review* 20, 2017, pp. 128-69: p. 132.
42 Juan Carlos Castilla-Rubio, Simon Zadek and Nick Robins, *Fintech and Sustainable Development: Assessing the Implications*, Geneva: United Nations Environment Programme, 2016, p. 31.
43 Juan Carlos Castilla-Rubio, "Nature-Inspired Design: How the Amazon can Help us Solve Humanity's Greatest Challenges," World Economic Forum, 25 June 2017, https://www.weforum.org/agenda/2017/06/bio-inspired-design-amazon-technology/.
44 Hernan de Soto Polar, *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else, New York:* Basic Books, 2000; Timothy Mitchell, "The Work of Economics: How a Discipline Makes its World," *European Journal of Sociology*, 46, 2, 2005, pp. 297-320; "Rethinking Economy," *Geoforum* 39, 2008, pp. 1116-1121.
45 Will O'Brien, "The Blockchain Finds Purpose on Richard Branson's Necker Island," *Medium*, 3 June 2015, https://medium.com/@willobrien/the-blockchain-finds-purpose-on-richard-branson-s-necker-island-338013d36ba1; Pete Rizzo, Block Chain Summit Responds to Backlash over Private Island Bash," *Coindesk*, 4 May 2015, https://www.coindesk.com/block-chain-summit-backlash-island-bash.
46 Giulio Prisco, "BitFury Announces Blockchain Land Titling Project With the Republic of Georgia and Economist Hernando De Soto," *Bitcoin Magazine*, 27 April 2016, https://bitcoinmagazine.com/articles/bitfury-announces-blockchain-land-titling-project-with-the-republic-of-georgia-and-economist-hernando-de-soto-1461769012/; "Bitfury, Republic of Georgia Push Ahead With Blockchain Land-Titling Project," Bitcoin Magazine, 8 February 2017, https://bitcoinmagazine.com/articles/bitfury-republic-georgia-push-ahead-blockchain-land-titling-project/.
47 Angel Milev, "Blockchain Startup Can Help Consumers Profit From Their Personal Data," *Cointelegraph,* 18 January 2018, https://cointelegraph.com/news/blockchain-startup-can-help-consumers-profit-from-their-personal-data, Don Tapscott, "Understand Blockchain in under 7 Minutes," Lloyds Bank, *YouTube*, 22 March 2018, https://www.youtube.com/watch?v=isuAPyuqS7Y.
48 See https://cosmochain.io/en/.

49 Don and Alex Tapscott, *Blockchain Revolution: How the Technology behind Bitcoin is Changing Money, Business and the World*, New York: Penguin, 2016, p.150.
50 Karl Marx. *Capital*, vol. 1, London: Penguin, 1990 [1867], pp. 342, 367, 406, 416, 598, 601, 875, 920, 926, 1007. For passages substituting "vital forces" for "blood" see also pp. 341, 348, 376-382, 557, 647, 851, 994.
51 Maria Mies, *Patriarchy and Accumulation on a World Scale: Women in the International Division of Labour*, London, Zed, 1999.
52 David Graeber, *Debt: The First 5000 Years*, London: Melville House, *2014.*
53 Matthew Huber, "Energizing Historical Materialism: Fossil Fuels, Space and the Capitalist Mode of Production," *Geoforum* 40, 1, pp. 105-115.
54 Harry Collins and Trevor Pinch, *The Golem at Large: What You Should Know about Technology*, Cambridge: Cambridge University Press, 2009.
55 Ludwig Wittgenstein, *Philosophical Investigations*, trans. Elizabeth Anscombe, Oxford: Blackwell, 1953; Saul Kripke, *Wittgenstein on Rules and Private Language*, Cambridge, MA: Harvard University Press, 1982; Martin Kusch, *A Sceptical Guide to Meaning and Rules: Defending Kripke's Wittgenstein*, London: Routledge, 2006.
56 Karl Marx, "Replacement of Labour by Machinery," *Economic Manuscripts of 1861-63*, https://marxists.catbull.com/archive/marx/works/1861/economic/ch35b.htm.
57 Tony Smith, "The Chapters on Machinery in the 1861-63 Manuscripts," in Riccardo Bellofiore and Roberto Fineschi (eds.), *Re-reading Marx: New Perspectives after the Critical Edition*, New York: Palgrave Macmillan, 2009, p. 124.
58 Guy Gugliotta, "Deciphering Old Texts, One Woozt, Curvy Word at a Time," *New York Times*, 28 March 2011.
59 Dallas Smythe, "On the Audience Commodity and Its Work" [1981], in Meenakshi G. Durham and Douglas M. Kellner (eds.), *Media and Cultural Studies,* Malden, MA: Blackwell, pp. 230–56.
60 Espen Gaarder Haug and Nassim Nicholas Taleb, "Why We Have Never Used the Black-Scholes-Merton Option Pricing Formula," 2007, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.581.884&rep=rep1&type=pdf.
61 Nanette Byrnes, "As Goldman Embraces Automation, Even the Masters of the Universe Are Threatened," *MIT Technology Review*, 7 February 2017.
62 Harry Collins and Martin Kusch, *The Shape of Actions: What Humans and Machines Can Do*, Cambridge, MA: MIT Press, pp. 142-146.
63 Alex Hern, "Facebook Translates 'Good Morning' into 'Attack Tthem', Leading to Arrest," *The Guardian,* 24 October 2017, https://www.theguardian.com/technology/2017/oct/24/facebook-palestine-israel-translates-good-morning-attack-them-arrest.
64 Paul Burawoy, *Manufacturing Consent: Changes in the Labour Process Under Monopoly Capitalism*, Chicago: University of Chicago Press, 1980; Paul Willis, *Learning To Labour*, Farnham: Ashgate, 1977; Gerd Spittler, "Contesting the Great Transformation: Work in Comparative Perspective", in Chris Hann and Keith Hart (eds.), *Market and Society: The Great Transformation Today*, Cambridge University Press, 2009, pp. 160-74; Slavoj Zizek, *The Plague of Fantasies*, London: Verso, 1997.
65 Dipesh Chakrabarty, "Universalism and Belonging in the Logic of Capital," Public Culture 12 (3), 2000, pp. 653-678.
66 Tim Mullaney, "Jobs Fight: Haves vs. the Have-Nots," *USA Today*, 16 September 2012.
67 Salvatore Veca, "Value, Labour and the Critique of Political Economy," trans. Silvia Federici, *Telos* 9, 1971, pp. 48-64.
68 Slavoj Zizek, *The Relevance of the Communist Manifesto*, London: Policy, 2019.
69 Karl Marx, "Replacement of Labour by Machinery," *Economic Manuscripts of 1861-63*, https://marxists.catbull.com/archive/marx/works/1861/economic/ch35b.htm.
70 Edan Yago, "Why the Wrong Response to The DAO Attack Could Kill Ethereum," *Coindesk*, 20 June 2016; https://www.coindesk.com/ethereum-response-dao-kill. See also Andrew R. Iglesias, "History of the Decentralized Autonomous Organization," Lund University, n.d., http://law.lu.se/webuk.nsf/(MenuItemByDocId)/ID9894504E310C9493C1258234004B30B6/$FILE/Andrew%20Iglesias%20-History%20of%20the%20DAO.pdf.
71 Ajay Agrawal, Joshua Gans and Avi Goldfarb, *Prediction Machines: The Simple Economics of Artificial Intelligence*, Cambridge, MA: Harvard Business Review Press, 2018.
72 Adam Geitgey, "Text Classification is Your New Secret Weapon," *Medium,* 15 August 2018, https://medium.com/@ageitgey/text-classification-is-your-new-secret-weapon-7ca4fad15788.
73 Juan Carlos Castilla-Rubio, Simon Zadek and Nick Robins, *Fintech and Sustainable Development: Assessing the Implications*, Geneva: United Nations Environment Programme, 2016, p. 4.
74 Jia Deng, Wei Dong, Richard Socher, Li-Jia Li, Kai Li and Li Fei-Fei, "ImageNet: A Large-Scale Hierarchical Image Database," Department of Computer Science, Princeton University, 2009, http://www.image-net.org/papers/imagenet_cvpr09.pdf.
75 Ivan Illich, *In the Vineyard of the Text: A Commentary to Hugh's* Didascalicon, Chicago: University of Chicago Press, 1993; *Shadow Work,* London: Marion Boyars, 1981; Walter Ong, *Orality and Literacy: The Technologizing of the Word,* New York: Routledge, 1982; H. M. Collins, *Artificial Experts: Social Knowledge and Intelligent Machines*, Cambridge,

MA: MIT Press, 1990.

76 Ludwig Wittgenstein, *Philosophical Investigations*, trans. Elizabeth Anscombe, Oxford: Blackwell, 1953, paragraph 455.

77 Ibid., paragraph 454.

78 Ibid., paragraph 198.

79 Ibid., paragraph 85.

80 Michael Oakeshott, *Rationalism in Politics and Other Essays*, Indianapolis: Liberty Fund, 1991, p. 52.

81 Ludwig Wittgenstein, *Philosophical Investigations*, trans. Elizabeth Anscombe, Oxford: Blackwell, 1953, paragraph 193.

82 Ibid., paragraphs 193-202, 78-79, 160.

83 Emin Gun Sirir, "Thoughts on the DAO Hack,", *Hacking, Distributed*, 17 June 2016, http://hackingdistributed.com/2016/06/17/thoughts-on-the-dao-hack/.

84 Evgeny Morozov, *To Save Everything, Click Here: The Folly of Technological Solutionism,* New York: Public Affairs, 2014.

85 E.g., Edan Yago, "Why the Wrong Response to The DAO Attack Could Kill Ethereum," *Coindesk*, 20 June 2016, https://www.coindesk.com/ethereum-response-dao-kill.

86 Tarleton Gillespie, "Algorithmically Recognizable: Santorum's Google Problem, and Google's Santorum Problem," *Information, Communication and Society* 20,1, pp. 63-80.

87 Harry Frankfurt, *On Bullshit*, Princeton: Princeton University Press, 2005.

88 Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication*, Urbana: University of Illinois Press, 1963.

89 Daniel Dennett, *From Bacteria to Bach and Back: The Evolution of Minds*, London: Penguin, 2018.

90 Compare David McNally, "Beyond the False Infinity of Capital", in Robert Albritton and John Simoulidis (eds.), *New Dialectics and Political Economy*, London: Palgrave Macmillan, 2003, p. 8.

91 Evgeny Morozov, *To Save Everything, Click Here: The Folly of Technological Solutionism,* New York: Public Affairs, 2014.

92 Ted Chiang, *The Lifecycle of Software Objects*, Burton, MI: Subterranean Press, 2010.

93 Judy Wacjman, *Pressed for Time: The Acceleration of Life in Digital Capitalism,* Chicago: University of Chicago Press, 2015.

94 Thomas Kuhn, *The Structure of Scientific Revolutions*, Chicago: University of Chicago Press, 1962,

95 Hannah Fry, *Hello World: Being Human in the Age of Algorithms,* New York: Norton, 2018, pp. 32-48.

96 Reni Eddo-Lodge, *Why I'm No Longer Talking to White People about Race*, London: Bloomsbury, 2018; Ghassan Hage, *Is Racism an Environmental Threat?*, London: Policy, 2017.

97 Helen Nissenbaum, "After the Tornado," *YouTube*, 19 November 2017, https://www.youtube.com/watch?v=IodheRG8r2w&feature=youtu.be.

98 Julia Powles, "The Seductive Diversion of 'Solving' Bias in Artificial Intelligence," *Medium,* 7 December 2018, https://medium.com/s/story/the-seductive-diversion-of-solving-bias-in-artificial-intelligence-890df5e5ef53.

99 Don and Alex Tapscott, *Blockchain Revolution: How the Technology behind Bitcoin is Changing Money, Business and the World*, New York: Penguin, 2016, p. 156.

100 Stephen Marglin, *The Dismal Science: How Thinking Like an Economist Undermines Community,* Cambridge, MA: Harvard University Press, 2008, pp. 153-4.

101 David Roediger and Elizabeth Esch, "'One Symptom of Originality': Race and the Management of Labour in US History", in David Roediger, *Class Race and Marxism*, London: Verso, 2017, chapter 5.

102 See https://nori.com/.

103 Dong He, Karl Habermeier, Ross Leckow et al., "Virtual Currencies and Beyond: Initial Considerations," International Monetary Fund Discussion Note, Washington, DC: IMF, 2016, p. 23.

104 Catherine Tucker and Christian Catalini, "What Blockchain Can't Do," *Harvard Business Review,* 28 June 2018, https://hbr.org/2018/06/what-blockchain-cant-do.

105 Andrew Schmahl, Sanjaya Mohottala et al., "Resolving the Blockchain Paradox in Transportation and Logistics," Boston Consulting Group, 29 January 2019, https://www.bcg.com/en-gb/publications/2019/resolving-blockchain-paradox-transportation-logistics.aspx.

106 Jimmy Song, "The Truth about Smart Contracts," *Medium,* 11 June 2018, https://medium.com/@jimmysong/the-truth-about-smart-contracts-ae825271811f.

107 David Gerard, *Attack of the 50-Foot Blockchain: Bitcoin, Blockchain, Ethereum and Smart Contracts*, David Gerard, 2017.

108 James Crotty, "Structural Causes of the Global Financial Crisis: A Critical Assessment of the 'New Financial Architecture'," *Cambridge Journal of Economics* 33, 4, 2009, pp. 563–580.

109 Robert E. Scott, "A Theory of Self-Enforcing Indefinite Agreements," *Columbia Law Review* 103, 7, 2003, pp. 1641-1699.
110 Jimmy Song, "The Truth about Smart Contracts," *Medium,* 11 June 2018, https://medium.com/@jimmysong/the-truth-about-smart-contracts-ae825271811f. Cf. Alexander Tsankov, "The 'Oracle Problem' isn't a Problem, and why Smart Contracts makes Insurance better for everyone," *Medium*, 21 June 2018, https://medium.com/@antsankov/the-oracle-problem-isnt-a-problem-and-why-smart-contracts-makes-insurance-better-for-everyone-8c979f09851c.
111 Sherman Lee, "Blockchain Smart Contracts: More Trouble Than They Are Worth?", *Forbes*, 10 July 2018, https://www.forbes.com/sites/shermanlee/2018/07/10/blockchain-smart-contracts-more-trouble-than-they-are-worth/#7fa39d5e23a6.
112 Emile Durkheim, *The Division of Labour in Society*, New York: Free Press, 2014.
113 Robert W. Gordon, "Macneil, Macaulay, and the Discovery of Power and Solidarity in Contract Law," *Wisconsin Law Review*, 1985, pp. 565-579.
114 Ibid., p. 569.
115 Deborah Levy, "Book-Smart, Not Street-Smart: Blockchain-Based Smart Contracts and The Social Workings of Law," *Engaging Science, Technology, and Society* 3, 2017, pp. 1-15: p. 4.
116 Ibid., pp. 5-7.
117 Matt Levine, "Basic Income and Blockchain Courts," *Bloomberg*, 5 May 2016, https://www.bloomberg.com/opinion/articles/2016-05-05/basic-income-and-blockchain-courts.
118 Sanford Grossman and Oliver Hart, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy* 94, 4, 1986, pp. 691–719; Oliver Hart, *Firms, Contracts, and Financial Structure*, Oxford: Oxford University Press, 1995.
119 CleanApp, "Against Smart Contracts," *Medium,* 15 July 2018, https://medium.com/cryptolawreview/against-smart-contracts-4a1f43133215.
120 Digital Asset, "Smart Contract Language: The Real Arbiter of Truth?", *Medium*, 13 Junly 2018, https://medium.com/daml-driven/smart-contract-language-the-real-arbiter-of-truth-efe833031ca1.
121 Jeremy M. Sklaroff, "Smart Contracts and the Cost of Inflexibility," University of Pennsylvania Law School Prize Winning Papers. 9, 2018, https://scholarship.law.upenn.edu/prize_papers/9.
122 Larry Lohmann, "Law, Neoliberalism and Nature" in Philippe Cullet and Sujith Koonan (eds.) *Research Handbook on Law, Environment and Poverty*, London: Edward Elgar, forthcoming.
123 Jason W. Moore, *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*, London: Verso, 2015.
124 Rosemary Gillespie, "Ecological Release," in R.G. Gillespie and D.A. Clague (eds.), *Encyclopedia of Islands,* Berkeley: University of California Press, pp. 251-253.
125 Jason W. Moore, *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*, London: Verso, 2015.
126 John Haugeland, "Body and World: A Review of *What Computers Still Can't Do*: *A Critique of Artificial Reason* (Hubert L. Dreyfus)" *Artificial Intelligence* 80, 1996, pp. 119-128: p. 124.
127 https://digiconomist.net/ethereum-energy-consumption. accessed 20 April.
128 Adam Jezard, "In 2020 Bitcoin Will Consume More Power than the World does Today," World Economic Forum, 15 December 2017, https://www.weforum.org/agenda/2017/12/bitcoin-consume-more-power-than-world-2020/
129 Camilo Mora, Randi Rollins, et al., "Bitcoin emissions alone could push global warming above 2°C," *Nature Climate Change* 8, 2018, pp., 931–933.
130 Fuchs, Christian, "Capitalism, Patriarchy, Slavery, and Racism in the Age of Digital Capitalism and Digital Labour," *Critical Sociology* 44, 4-5, 2018, pp. 677-702*;* Fuchs, *Digital Labour and Karl Marx*, London: Routledge, 2014.
131 Marisol de la Cadena, *Earth Beings: Ecologies of Practice across Andean Worlds,* Durham: Duke University Press, 2015.
132 Juan Carlos Castilla-Rubio, Simon Zadek and Nick Robins, *Fintech and Sustainable Development: Assessing the Implications*, Geneva: United Nations Environment Programme, 2016, pp. 23-24.
133 "How 5G will Change the Future of Farming," *CNN Business*, 2 April 2019, https://edition.cnn.com/2019/04/01/business/5g-farming/index.html. See also http://www.handsfreehectare.com/.
134 Paul Seidler, Paul Kolling and Max Hampshire, "terra0: Can an Augmented Forest Own and Utilise itself?" Berlin University of the Arts, 2016, https://terra0.org/assets/pdf/terra0_white_paper_2016.pdf, p. 2.
135 Christian Fuchs, "Class and Exploitation on the Internet," in Trevor Scholz (ed.), *Digital Labour: The Internet as Playground and Factory*, London: Routledge, pp. 296-311: p. 311.
136 Andrew Ross, "In Search of the Lost Paycheck," in Trevor Scholz (ed.), *Digital Labour: The Internet as Playground and Factory*, London: Routledge, pp. 24-51: p. 44.
137 Jack Linchuan Qiu, *Goodbye iSlave*, pp. 25-26, 35. See also Pun Ngai and Jenny Chan, "Global Capital, the State, and Chinese Workers: The Foxconn Experience," *Modern China* 38, 4, 2012, pp. 383-410; Jenny Chan and Ngai Pun, "Suicide as Protest for the New Generation of Chinese Migrant Workers: Foxconn, Global Capital, and the State," *Asia-Pacific Journal*, Japan Focus 8, 37, http://japanfocus.org/-jenny-chan/; Ngai Pun, "Becoming *Dagongmei* (Working

Girls): The Politics of Identity and Difference in Reform China," *China Journal* 42, 1999, pp. 1–18.

138 James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed,* New Haven: Yale University Press, 1999.

139 David Harvey, *Seventeen Contradictions and the End of Capitalism*, London: Profile, 2014.

140 Michael Perelman, *The Invention of Capitalism: Classical Political Economy and the Secret History of Primitive Accumulation*, Durham: Duke University Press, 2000; Steven Colatrella, *Workers of the World: African and Asian Migrants in Italy in the 1990s*, Africa Research and Publications, 2002.

141 E. P. Thompson, *Customs in Common: Studies in Traditional Popular Culture*, New York: The New Press, 1990, p. 159.

142 Octave Mannoni, "'I Know Well, but All the Same ...'," in Molly Anne Rothenberg, Dennis Foster, and Slavoj Zizek (eds.), *Perversion and the Social Relation*, Durham: Duke University Press, 2003, pp. 68-92.

143 Slavoj Zizek, "Abjection, Disavowal, and the Masquerade of Power," *Journal of the Centre for Freudian Analysis and Research* 26, 2015, http://jcfar.org.uk/jcfar-bookshop/articles/jcfar-26-slavoj-zizek/.

144 CleanApp, "Why's Szabo Afraid of 'Smart Contract' Critiques?", *Medium*, 17 October 2018, https://medium.com/cryptolawreview/whys-szabo-afraid-of-smart-contract-critiques-669ef9e63fc0.

145 See for example, William Casey and Paul Vigna, *The Truth Machine: The Blockchain and the Future of Everything*, New York: St. Martin's Press, 2018.

146 Eric Pineault, "Growth and Over-accumulation in Advanced Capitalism: Some Critical Reflections on the Political Economy and Ecological Economics of Degrowth," Working Paper, DFG-Kollegforscher innengruppe Postwachstumsgesellschaften, Freidrich-Schiller-Universitat, Jena, 2016, http://www.kolleg-postwachstum.de/sozwgmedia/dokumente/WorkingPaper/wp5_2016+Pineault.pdf.

147 Trustnodes, "Vitalik Buterin: Blockchains of the Future Will be Thousands of Times More Efficient," 11 December 2018, https://www.trustnodes.com/2018/12/11/vitalik-buterin-blockchains-of-the-future-will-be-thousands-of-times-more-efficient.

148 Slavoj Zizek, *For They Know not What They Do: Enjoyment as a Political Factor*, London: Verso, 2007.

149 Slavoj Zizek, "Happiness as an Ideological Category," in *Madam, I'm Adam: The Organization of Private Life,* Brugge: De Keure, 2003, pp. 114-130. See also Robert Pfaller, "Where is Your Hamster? The Concept of Ideology in Slavoj Zizek' s Cultural Theory," in Geoff Boucher, Jason Glynos and Matthew Sharpe, *Traversing the Fantasy: Critical Responses to Slavoj Zizek,* Aldershot: Ashgate, 2005.

150 Brian Merchant, "Fully Automated Luxury Communism," *The Guardian,* 18 March 2015, https://www.theguardian.com/sustainable-business/2015/mar/18/fully-automated-luxury-communism-robots-employment.

151 Vitalik Buterin, "DAOs, DACs, DAs and More: An Incomplete Terminology Guide," Ethereum Blog, 6 May 2014, https://blog.ethereum.org/2014/05/06/daos-dacs-das-and-more-an-incomplete-terminology-guide/.

152 Daniel Suarez, *Daemon,* New York: Dutton, 2009.

153 Slavoj Zizek, *The Sublime Object of Ideology*, London: Verso, 2989, pp. 32-33.

154 George Caffentzis, "On Africa and Self-Reproducing Automata," "Why Machines Cannot Create Value: Marx's Theory of Machines," "Marx, Turing Machines and the Labour of Thought," "Crystals and Analytic Engines: Historical and Conceptual Preliminaries to a New Theory of Machines," in George Caffentzis, *In Letters of Blood and Fire: Work, Machines and the Crisis of Capitalism*, Oakland: PM Press, 2013, pp. 127-200.