How Carbon Trading Became a Way of Life for California's Yurok Tribe

By Carolyn Kormann

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A carbon-offset project, the first of its kind in the United States, has become the Yurok's main source of discretionary income, helping the tribe buy back thousands of acres of land.

Photograph by Joel Redman

When Marty Lamebear is not fighting fires, he is starting them. In the past few years, as a member of the Yurok Tribe Forestry Program's fire department, he has been helping revive the controversial practice of prescribed burns to protect and restore the coastal redwood forests of northern California. Lamebear is also a hunter, fisherman, and dancer. In his free time, he makes tribal regalia for ceremonial dances from parts of elk, deer, minks, and porcupines, which he shoots or finds already dead, and from frozen eagles that he orders from the U.S. Fish and Wildlife Service. A prescribed burn, what Lamebear calls a culture burn, creates prairies within the forest, which attract those animals. "At first, we couldn't really tell its effects," he said. "But, after about six years now, we can honestly start seeing the landscape open up, animals come around." They also serve another purpose, he said. "It's insurance for our carbon."

According to archaeological records and oral history, Yurok lands originally stretched across some half a million acres. But in 1855 the United States confined the tribe to a reservation that covered less than a fifth of that expanse, or roughly ninety thousand acres. The borders narrowly straddled the Klamath River, which teemed with salmon, running inland about forty-five miles, from the Pacific Coast south, into Humboldt County. In subsequent years, the federal government took away most of that land as well, opening it to white homesteaders, gold miners, and timber companies, and later claiming some of it for itself—for the Forest Service or national parks. By the nineteen-nineties, the tribe was left with only five per cent of its original reservation, an area roughly a third the size of Manhattan. As Yurok leaders wrote in the preamble to their 1993 constitution, "Our social and ecological balance, thousands and thousands of years old, was shattered by the invasion of the non-Indians."

In those years, Yurok leaders considered filing lawsuits claiming that the surrounding lands were rightfully theirs. But lawyers advised against it. "They said, 'If you go to court, you might lose, so then you lost all that money, all that time,' " Dale Webster, a founding

member of the tribal council, told me. The lawyers advised that "it's cheaper to just buy it back." Ninety-five per cent of the tribal government's budget comes from federal grants. The tribe's salmon fishery—central to its identity and its economy—has been decimated, largely by upstream agriculture and four hydroelectric dams. Jobs are scarce. Eighty per cent of the tribe lives below the poverty line. Opioid and heroin abuse has increased in the community to the point that, as Dawn Baum, the tribe's deputy general counsel, told me, "It's not just that you know someone who's been affected. You probably know someone who's died." For years, finding the resources to purchase Yurok land—and restore the forests, watersheds, and salmon fisheries—seemed impossible. "People love to have doom-and-gloom stories about Indians," Baum said. "And it's true—our connection to the land means that, when we don't have fish, it really affects us."

Lamebear's job came to exist—the Yurok Fire Department came to exist—because the tribe, the largest in California, finally began to buy back its land through a program that remains both a matter of dispute and a mystery to many of the tribe's members. Around 2010, Yurok leaders began negotiating a way to participate in California's cap-and-trade program. For each metric ton of carbon that the tribe can prove its forests have sequestered from the atmosphere, the California Air Resources Board (*CARB*), the state agency that regulates air quality and emissions, issues the tribe one offset credit. Polluting industries can then buy the Yurok's offsets in order to comply with the state's greenhouse-gas-emissions cap. "They're getting paid for carbon," Webster said. "For all these trees along the river, where the prairie used to be, where all the deer and the elk used to come through."

The Yurok's carbon-offset project, among the first of its kind in the United States, has become the tribe's main source of discretionary income. It has helped the tribe buy back, to date, nearly sixty thousand acres—up from five thousand. "This has been a way for us to revive the economy in a way that aligned with our cultural values," Amy Cordalis, the tribe's general counsel, said. The program has been touted by environmental organizations as a possible model for other indigenous groups living in forests around the world to regain their rights, while working with national and provincial governments to combat climate change. Seven other indigenous entities in the U.S. are now also selling carbon offsets.

The move has remained controversial among the Yurok. The decision came with a suite of concessions to the state government, including a nominal loss of sovereignty and greater environmental oversight. Several people I spoke with questioned the ethics of a program that seems to offer a license for industry pollution. "I think we did a good thing by saving the trees, but I'm not happy with it," Jene McCovey, a tribal elder, told me. "It's not viable. It allows polluters to pollute." The Yurok believe in cultivating a symbiotic relationship with nature; given the way things are now, she said, "If you're an eagle looking down on earth, you can't find balance at all."

In order to obtain verified offset credits, the tribe had to meet *CARB*'s strict protocols for improved forest management. In essence, as long as the tribe maintains healthy redwoods, firs, and other native species, it can sell the photosynthesis that those trees perform. Lamebear's department is, counterintuitively, using fire as one tactic to achieve that end, burning forty to fifty acres at a time, in the spring and fall. (Fire experts have only recently accepted the wisdom of burning fuel loads to reduce wildfire risk, a practice the Yurok had

undertaken, often in opposition to state laws, for decades). The California Department of Forestry and Fire Protection still has to approve the burn plans, and oversee their execution, but Lamebear said, "Eventually we'll be able to do it ourselves. That's our No. 1 goal, to take our own land and do what we want with it." This means conserving their forests in ways that incorporate both current science and traditional knowledge. "We're trying to keep wildfires from getting out of hand," he said. "If we put everything we have into the carbon project, then a wildfire rips through it, what good is the carbon then?"

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Photograph by Joel Redman

In 2006, California passed the Global Warming Solutions Act, which set a goal of reducing the state's greenhouse-gas emissions to 1990 levels by 2020, and an additional forty per cent by 2030, while also strengthening the economy. To achieve these targets, in 2011, *CARB* adopted the first multi-sector cap-and-trade program for regulating planet-warming emissions in the United States. The program set a limit, or cap, on statewide greenhouse-gas emissions that decreases by two to three per cent each year. Companies in the state must obtain permits, or allowances, from *CARB* for each metric ton of carbon dioxide (or its equivalent, such as methane) that they send into the atmosphere—that is, their share of the statewide emissions pie. As that pie shrinks, companies have several options: they can upgrade their facilities to operate more efficiently, burn less fossil fuel, and—fulfilling the trade part of "cap and trade"—buy allowances from other companies who have already significantly lowered their emissions. Companies can also fulfill a small percentage of their compliance obligations by purchasing carbon-offset credits from forestry projects like the Yurok tribe's.

Proponents argue that offsets give companies time and flexibility to meet the cap as it goes down each year, to reduce the economic burden, while still reducing over-all emissions across the state. "This is not a free ticket for polluters," Maria DiGiano, a scientist from the nonprofit Earth Innovation Institute, said. Companies are currently limited to using offsets to cover eight per cent of their emissions, and that number drops to four per cent by 2020. To date, offsets represent only about two per cent of the total emissions cap—mostly from forestry projects, but also from efforts like "dairy digesters," which capture cows' methane emissions. But there is evidence that they can have a tremendous impact. Last year, researchers from Stanford University published a study that found California's forestry-offset programs have led to emissions reductions from land that likely otherwise would have been logged, and helped conserve habitat for endangered species. In a report released recently on how the U.S. can still meet the Paris Agreement climate targets in the absence of federal leadership, land management—of forests and farms—was listed as one of the strategies with the greatest future potential for emissions reductions.

For the Yurok, the sale of forest offsets "is huge," Ed Mann, the tribe's new forestry director, told me. "It's not chump change. It's millions of dollars every year." Currently, a single carbon offset has been valued at approximately twelve dollars. *CARB* has so far issued the Yurok two million offset credits. (Of about ninety million forestry offsets that *CARB* has issued, half, worth roughly five hundred million dollars, went to the Alaska Native corporation and other tribal projects, including the Yurok's.) The Yurok tribe has a package of credits coming on the market this fall expected to bring in upwards of five million dollars.

It wasn't clear at first that the Yurok would be able to sell carbon offsets at all. When *CARB* was still writing the regulations for a compliance cap-and-trade program, tribal lands were thought to be ineligible—just as federal lands were ineligible—since the state lacked jurisdiction. *CARB*needed to be able to enforce its forest-offset rules and take punitive action against landowners whose forests failed to sequester or store the amount of carbon that was sold. "We honestly didn't even think to ask," Jason Gray, a *CARB* attorney in charge of the cap-and-trade program said. Once some Yurok tribal leaders heard about the forest offsets, however, they moved to find a way to be included. This became legally complicated; *CARB* had to write a provision that gave the agency regulatory authority over Yurok lands, while still respecting the Yurok's rights. Ultimately, the Yurok agreed to a limited waiver of the sovereign immunity that it holds as an indigenous nation. "It's very sensitive," Gray said. "Nobody wants to waive their sovereignty."

Mann, who speaks with a soft twang, as if narrating a fairy tale, is not a tribal member; before the Yurok hired him, last year, he had worked for the Spokane tribe and the Yakama Tribe as a silviculturist—planning and preparing timber harvests, and managing forests, including the use of prescribed burns, to keep them healthy for other environmental and cultural purposes. He is now responsible for overseeing the Yurok's entire carbon-offset program, and all the Yurok's new lands. The tribal council previously relied on brokers—sometimes called carbon cowboys—to market and sell their offsets. Mann has ended that era, bringing everything in house. The tribe now monitors the state of the cap-and-trade market, asking for bids on their offsets to see what the market will support, and attempting to sell when the price on carbon is high. By eliminating the middlemen, Mann said, the tribe can now "vet potential buyers in terms of social- and economic-justice issues." Mann has been thinking about giving trees' carbon an economic value since the nineteen-eighties, when the idea was first raised in conservation circles. "It's a forester's dream," he told me. "Finally, we have created a value for forests without having to cut them down."

California is among the largest cap-and-trade markets in the world, along with the European Union, South Korea, and, most recently, China. Offsets play a relatively small role in these markets over-all, but efforts are underway to expand their reach to tropical forests, which have vast potential for mitigating global climate change. Until recently, the lush vegetation of the Amazon, and other tropical forests, have been considered a colossal carbon sink. But, according to a 2017 paper published in *Science*, tropical rainforests are now a net carbon source. If major industries keep slashing and burning the world's rainforests at the current rate, the chance that countries will meet the Paris goals—limiting global warming to no more than two degrees Celsius—rapidly plummets. Improving forest

management and protections , on the other hand, could reduce emissions by an amount greater than vaporizing every car in the world.

A number of experts now believe that reclaiming land for indigenous people is the best way to protect the Earth's forests. According to the Rights and Resources Initiative, an N.G.O. that advocates for native land rights, legally recognized indigenous forests "tend to store more carbon and experience lower rates of deforestation." But in a recent report supported by data from the Woods Hole Research Center, the initiative found that while indigenous communities currently manage forests and soil containing nearly three hundred billion metric tons of carbon—thirty-three times more than global energy-related emissions in 2017—they lacked legal titles to the sites of at least a third of that carbon total." This puts "them, their forests and the carbon they store at great risk," Alain Frechette, one of the authors of the initiative's report, said. Recognizing those rights, the authors argue, is the best way to prevent deforestation and keep the carbon in the trees and soil.

In mid-September, a climate summit in San Francisco co-hosted by California's governor, Jerry Brown, and Michael Bloomberg, the billionaire former mayor of New York City, drew more than four thousand delegates from six continents. Protesters calling for an end to fossil fuels and carbon markets blocked the entrance, leading to police removals and at least two arrests. "Here we've got environmentalists protesting an environmental conference," Bloomberg said at a press conference. "It reminds me of people who want to build a wall along the Mexican border to keep people out from a country that we go to for vacations. Something's crazy here."

But critics of emissions trading have their reasons: communities located near wells, plants, and pipelines, which tend to be poorer and home to people of color, must still breathe polluted air; for oil and gas companies, buying carbon offsets amounts to escaping accountability for the harm they are causing these communities; and allowing fossil-fuel industries to buy offsets rather than reduce their own emissions delays the process of phasing out polluting practices entirely. When I met with Angela Adrar, the executive director of the Climate Justice Alliance, and one of the protest's organizers, I suggested that carbon markets weren't all bad—they had, for instance, allowed the Yurok to reacquire their lands. She offered a small smile and shook her head. "The Yurok should have their land regardless of some program," she said. "They have rights that are not being respected. The fact that they have to sell their forest to get back their land seems really backwards."

The Yurok's lands used to narrowly straddle the Klamath River, which historically teemed with salmon, running inland from the Pacific Coast south into Humboldt County.
Photograph by Joel Redman

The week before the climate summit, a delegation of indigenous leaders from tropical forests in Latin America (primarily the Amazon) and Indonesia, had set up camp in the Redwood R.V. park, in the tiny village of Klamath, the seat of Yurok government. For years, *CARB* has been discussing ways to include tropical-forest offsets in its cap-and-trade program; the board issued a "draft standard," a model for how such a regulation, in theory, could work in other carbon markets, like China's, in the run-up to the summit. But it was unlikely that such a standard would be enacted in California anytime soon. The state would need a trusted subnational partner—a provincial government in the Amazon, for instance—to insure that all the project's data was public and viewable, that the rigor of the verification standards and methodologies were the same, and that the project engaged with indigenous communities to safeguard their rights. "We have a lot of enforcement mechanisms here in the U.S.," Gray told me. "We can make sure that projects are following the right protocol, that we are able to take some action if not. Internationally we don't have that."

The Yurok director of self-governance, Javier Kinney, had invited the delegation—with funding from the Ford Foundation—to learn about the Yurok's carbon-offset program, and to join forces in the pursuit of greater indigenous rights. Early one morning, the group assembled for a hike, led by Mann and some of his crew, including Lamebear, into the Yurok Redwood Experimental Forest. We followed a narrow path that led to an opening in the brush, where an enormous six-hundred-year-old redwood grew like the leaning tower of Pisa. In the clearing, the coördinating scientist from the U.S. Forest Service, a man named Frank Lake, who wore a hard hat and black studs in his ears, introduced himself. Lake grew up in the area, his half siblings are Yurok, and his research has focussed on the scientific evidence that backs indigenous ways of managing land. He recently published a paper that showed the benefits of the traditional Yurok practice of setting fires to call in the salmon—the smoke over the river lowers the water's temperature; colder water attracts more fish.

At the base of two more colossal redwoods, a woman from Brazil broke into song. An activist filmed her, the gray fuzzy boom mike sticking up like a gigantic thistle. Big conifers such as these store the most carbon, but they are especially vulnerable to the changing climate. Smaller trees such as tanoak and red alder may have much shorter life spans, but they sequester more carbon than redwoods and firs when they are young and growing fast. That's why it's best to have a balance of different species, ages, and forest habitats, Lake said. "If you have areas like oak woodlands, and oakland prairies, you have a different, more resilient type of forest diversity, one that still sequesters the same amount of carbon over an eighty-to-a-hundred-year time frame."

Lake is now devising a plan for how the Yurok and Forest Service can manage the area and conduct research together. (No national forest has ever been co-managed with a tribe.) "Historically, cultural burning added biodiversity and resources that the tribe depends on," he said. "It's important for the conservation community and environmentalists to understand the long history of people and forests together, and to promote those same relationships to conserve that biodiversity and cultural practice."

As we continued our hike, I caught up with Lamebear. “My grandparents grew up burning their own areas,” Lamebear said. “Illegally. But that didn’t stop them. With our generation, it’s been up to us to move in that gray legal area, so we stopped burning. Now we’re trying to pick up where they left off.” Lamebear stopped walking and examined the vegetation along the path. He thought he had seen black fern, a plant that Yurok women, including his mother and aunts, used to weave into baskets. The previous night, I had met a tribal elder named Dale Ann Sherman, who, after introducing herself to the visiting delegation, said, “Our women are internationally known for their basket weaving and their intelligence and bravery.” Old Yurok baskets from the nineteenth and early twentieth centuries are treasured. Some of the revenue from the sale of carbon offsets was used to buy back two large collections of Yurok baskets, which had previously been in private hands.

Lamebear acknowledged that the carbon project was bringing in money, which was good. But he also acknowledged the program’s shortcomings. “Our neighboring tribe, the Hupa, is looking into it now, how we’re bringing in money with our carbon credits. And how we’re selling ’em to these big industries so they can keep doing what they do,” he said. “They buy our air, so they can, you know, pollute theirs.”

Later that night, after a traditional cookout of fresh salmon (on redwood sticks around a fire pit), I sat down with David Gensaw, the vice-chair of the tribal council. Gensaw, who is sixty-three, has round cheeks and a wiry grey goatee. The night air was cool, and he wore a white-and-blue knit hat, woven in a pattern common to Yurok baskets. Gensaw voted against the carbon project initially. “It was a major decision,” he told me. “I thought it should go to the people for a general vote. This is just what happened in the past. Decisions getting made about our people’s land without their knowledge.”

Gensaw was understandably wary. He has spent his life dealing with discrimination, assault, and encroachment from the federal government. In 1978, when Gensaw was twenty-four years old, U.S. federal marshals arrived on the Klamath River, wearing full riot gear and carrying M-16s. His family and community had been fishing for salmon, as the tribe had done for thousands of years. But the federal government had declared a moratorium in the Klamath. After an automobile accident ended Gensaw’s logging career, he decided to go back to school. He was in his thirties but could read only at a fifth-grade level. At Humboldt State, he took part in the protests to preserve a threatened Native American-studies program. He graduated in 2008 and has been a council member for most of the years since. When the carbon project came along, he said, not everyone on the tribal council understood its ramifications, that it would lock their forests as carbon pools for a hundred years. The Yurok’s land, he said, “was stolen from us. What’s happened to us, right now, is that we don’t have the land, but in the future we’re gonna pay for it? After losing it?”

The next morning, the fog was cold and low over the dark river. Kinney and Cordalis, the Yurok’s lawyers, were giving a few members of the tropical delegation a boat tour up to Blue Creek, the most recent and important piece of land that the Yurok had acquired—their “stairway to heaven,” as Cordalis described it. The purchase had been drawn out and difficult. Green Diamond, the timber company that owned most of the land the Yurok has reacquired, did not want to sell an area rich with valuable redwood growth. (The other acreage they had sold to the Yurok was upstream from the redwood zone.) When I reached

the company's vice-president, Neal Ewald, by phone recently, he was on a trip to South Africa. "I'm a scuba diver, and I'm diving with sand-tiger sharks tomorrow," he said. Ewald explained that he had been in land-sale negotiations with the Yurok since the early nineties. "The Blue Creek was very tough for us to come to the conclusion to offer up," he said. After many conversations, he said, it became clear how important it was to the Yurok culture. "It's sort of their heartland, if you will," he said. "But it was a painful thing to sell the Blue Creek piece because it's so wonderful."

On the red jet boat, Tuntiak Katan, the territory and natural-resources director for the Confederation of Indigenous Nationalities of the Ecuadorian Amazon, was along for the ride. He carried the colorful headband that he had been wearing all week—made from toucan and tanager feathers—in a plastic food container. He was impressed with how the Yurok community has been able to maintain "their cosmology, and develop their vision, without isolating themselves from political and cultural systems that are different from theirs," and said that could see that "selling carbon has generated benefits to the community here." But, he added, "in the Amazon, if a company wants to pay to conserve our forests, they must also, simultaneously, reduce their own emissions. They can't buy our carbon, then keep polluting air. That's not going to work for us."

Kinney said that the carbon program was a compromise, and while it worked for the Yurok tribe, that didn't mean it was going to work for everyone. What mattered was "that tribes have a seat at the table," he said. "We need to be decision makers in the management of our natural resources. That's our main objective." As we approached the river mouth, there were barking seals, careening gulls, and salmon swimming out to sea. Someone pointed up to the tops of the trees lining the opposite shore, next to a site where the Yurok held one of their ceremonial dances. There, perched on a towering fir, staring down at us, sat a bald eagle.

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The Blockchain Economy: A beginner's guide to institutional cryptoeconomics

Chris Berg, Sinclair Davidson and Jason Potts are from the RMIT Blockchain Innovation Hub, the world's first social science research centre into the economics, politics, sociology, and law of blockchain technology.

The blockchain is a digital, decentralised, distributed **ledger**.

Most explanations for the importance of the blockchain start with Bitcoin and the history of money. But money is just the first use case of the blockchain. And it is unlikely to be the most important.

It might seem strange that a ledger — a dull and practical document associated mainly with accounting — would be described as a revolutionary technology. But the blockchain matters because ledgers matter.

Ledgers all the way down

Ledgers are everywhere. Ledgers do more than just record accounting transactions. A ledger consists simply of data structured by rules. Any time we need a **consensus** about **facts**, we use a ledger. Ledgers record the facts underpinning the modern economy.

Ledgers confirm ownership. Property title registers map who owns what and whether their land is subject to any caveats or encumbrances. Hernando de Soto has documented how the poor suffer when they own property that has not been confirmed in a ledger. The firm is a ledger, as a network of ownership, employment and production relationships with a single purpose. A club is a ledger, structuring who benefits and who does not.

Ledgers confirm identity. Businesses have identities recorded on government ledgers to track their existence and their status under tax law. The register of Births Deaths and Marriages records the existence of individuals at key moments, and uses that information to confirm identities when those individuals are interacting with the world.

Ledgers confirm status. Citizenship is a ledger, recording who has the rights and is subject to obligations due to national membership. The electoral roll is a ledger, allowing (and, in Australia, obliging) those who are on that roll a vote. Employment is a ledger, giving those employed a contractual claim on payment in return for work.

Ledgers confirm authority. Ledgers identify who can validly sit in parliament, who can access what bank account, who can work with children, who can enter restricted areas.

At their most fundamental level, ledgers map economic and social relationships. Agreement about the facts and when they change — that is, a consensus about what is in the ledger, and a trust that the ledger is accurate — is one of the fundamental bases of market capitalism.

Ownership, possession, and ledgers

Let's make a distinction here that is crucial but easy to miss: between **ownership** and **possession**.

Take passports. Each country asserts the right to control who crosses its borders, and each country maintains a ledger of which of its citizens have the right to travel. A passport is a physical item — call it a **token** — that refers back to this ledger.

In the pre-digital world, possession indicated ownership of that right. The Australian passport ledger consisted of index cards held in by the government of each state. Border agents presented with a passport could surmise that the traveller who held it was listed on a distant ledger as allowed to travel. Of course this left border control highly exposed to fraud.

A Belgian passport held by the Australian National Archives, A435 1944/4/2579

Possession *implies* ownership, but possession is *not* ownership. Now modern passports allow the authorities to confirm ownership directly. Their digital features allow airlines and immigration authorities to query the national passport database and determine that a passenger is free to travel.

Passports are a relatively straightforward example of this distinction. But as Bitcoin has shown: **money is a ledger, too**.

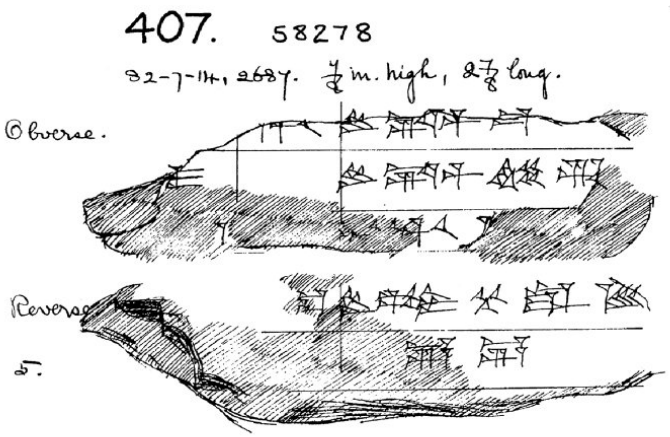
Possession of a banknote token indicates ownership. In the nineteenth century the possessor — 'bearer' — of a banknote had a right to draw on the issuing bank the value of the note. These banknotes were direct liabilities for the issuing bank, and were recorded on the banks' ledger. A regime of possession indicating ownership meant that banknotes were susceptible to be both stolen and forged.

In our era fiat currencies a five dollar bill cannot be returned to the central bank for gold. But the relationship remains — the value of the bill is dependent on a social consensus about the stability of the currency and government that issued it. Banknotes are not wealth, as Zimbabweans and Yugoslavians and Weimar Republic Germans have unfortunately learned. A bill is a call on a relationship in a (now synthetic) ledger and if that relationship collapses, so does the value of the bill.

The evolution of the ledger

For all its importance, ledger technology has been mostly unchanged … until now.

Ledgers appear at the dawn of written communication. **Ledgers and writing developed simultaneously** in the Ancient Near East to record production, trade, and debt. Clay tablets baked with cuneiform script detailed units of rations, taxes, workers and so forth. The first international 'community' was arranged through a structured network of alliances that functioned a lot like a distributed ledger.



A fragment of a late Babylonian cuneiform ledger, held by the British Museum, 58278

The first major change to ledgers appeared in the fourteenth century with the invention of **double entry bookkeeping**. By recording both debits and credits, double entry bookkeeping conserved data across multiple (distributed) ledgers, and allowed for the reconciliation of information between ledgers.

The nineteenth century saw the next advance in ledger technology with the rise of large corporate firms and large bureaucracies. These **centralised ledgers** enabled dramatic increases in organisational size and scope, but relied entirely on **trust** in the centralised institutions.

In the late twentieth century ledgers moved from analog to **digital ledgers**. For example, in the 1970s the Australian passport ledger was digitised and centralised. A database allows for more complex distribution, calculation, analysis and tracking. A database is computable and searchable.

But a database still relies on trust; a digitised ledger is only as reliable as the organisation that maintains it (and the individuals they employ). It is this problem that the blockchain solves. The blockchain is a distributed ledgers that does not rely on a trusted central authority to maintain and validate the ledger.

Blockchain and the economic institutions of capitalism

The economic structure of modern capitalism has evolved in order service these ledgers.

Oliver Williamson, the 2009 Nobel laureate in economics, argued that people produce and exchange in markets, firms, or governments depending on the relative **transactions costs** of each institution. Williamson's transactions cost approach provides a key to understanding what institutions manage ledgers and why.

Governments maintain ledgers of authority, privilege, responsibility and access. Governments are the trusted entity that keeps databases of citizenship and the right to travel, taxation obligations, social security entitlements, and property ownership. Where a ledger requires coercion in order to be enforced, the government is required.

Firms also maintain ledgers: proprietary ledgers of employment and responsibility, of the ownership and deployment of physical and human capital, of suppliers and customers, of intellectual property and corporate privilege. A firm is often described as a 'nexus of contracts'. But the value of the firm comes from the way that nexus is ordered and structured — the firm is in fact a ledger of contracts and capital.

Firms and governments can use blockchains to make their work more efficient and reliable. Multinational firms and networks of firms need to reconcile transactions on a global basis and blockchains can allow them to do so near-instantaneously. Governments can use the immutability of the blockchain to guarantee that property titles and identity records are accurate and untampered. Well-designed permissioning rules on blockchain applications can give citizens and consumers more control over their data.

But blockchains also compete against firms and governments. The blockchain is an institutional technology. It is a new way to maintain a ledger — that is, coordinate economic activity — distinct from firms and governments.

Before 2009				
	Hierarchy			
	Government	Firms	Market	
After 2009				
Government	Blockchain	Firms	Blockchain	Markets

The new economic institutions of capitalism

Blockchains can be used by firms, but they can also *replace* firms. A ledger of contracts and capital can now be decentralised and distributed in a way they could not before. Ledgers of identity, permission, privilege and entitlement can be maintained and enforced without the need for government backing.

Institutional cryptoeconomics

This is what institutional cryptoeconomics studies: the institutional consequences of cryptographically secure and trustless ledgers.

Classical and neoclassical economists understand the purpose of economics as studying the production and distribution of scarce resources, and the factors which underpinned that production and distribution.

Institutional economics understands the economy as made of rules. Rules (like laws, languages, property rights, regulations, social norms, and ideologies) allow dispersed and opportunistic people to coordinate their activity together. Rules facilitate exchange — economic exchange but also social and political exchange as well.

What has come to be called cryptoeconomics focuses on the economic principles and theory underpinning the blockchain and alternative blockchain implementations. It looks at game theory and incentive design as they relate to blockchain mechanism design.

By contrast, ***institutional*** **cryptoeconomics looks at the institutional economics of the blockchain and cryptoeconomy.** Like its close cousin institutional economics, the economy is a system to coordinate exchange. But rather than looking at rules, institutional cryptoeconomics focuses on ledgers: data structured by rules.

Institutional cryptoeconomics is interested in the rules that govern ledgers, the social, political, and economic institutions that have developed to service those ledgers, and how the invention of the blockchain changes the patterns of ledgers throughout society.

The economic consequences of the blockchain

Institutional cryptoeconomics gives us the tools to understand what is happening in the blockchain revolution — and what we can't predict.

Blockchains are an experimental technology. Where the blockchain can be used is an entrepreneurial question. Some ledgers will move onto the blockchain. Some entrepreneurs will try to move ledgers onto the blockchain and fail. Not everything is a blockchain use case. We probably haven't yet seen the blockchain killer app yet. Nor can we predict what the combination of ledgers, cryptography, peer to peer networking will throw up in the future.

This process is going to be extremely disruptive. The global economy faces (what we expect will be) a lengthy period of uncertainty about how the facts that underpin it will be restructured, dismantled, and reorganised.

The best uses of the blockchain have to be 'discovered'. Then they have to be implemented in a real world political and economic system that has deep, established institutions that already service ledgers. That second part will not be cost free.

Ledgers are so pervasive — and the possible applications of the blockchain so all-encompassing — that some of the most fundamental principles governing our society are up for grabs.

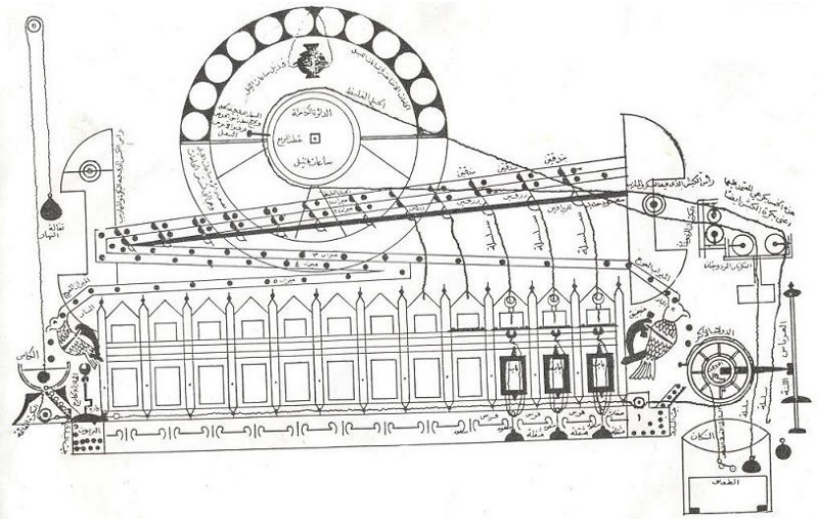
Institutional creative destruction

We've been through revolutions like this before.

It is common to compare the invention of Bitcoin and the blockchain with the internet. The blockchain is Internet 2.0 — or Internet 4.0. The internet is a powerful tool that has revolutionised the way we interact and do business. But if anything the comparison undersells the blockchain. The internet has allowed us to communicate and exchange better — more quickly, more efficiently.

But the blockchain allows us to exchange *differently*. **A better metaphor for the blockchain is the invention of mechanical time.**

Before mechanical time, human activity was temporally regulated by nature: the crow of the rooster in the morning, the slow descent into darkness at night. As the economic historian Douglas W. Allen argues, the problem was variability: "there was simply too much variance in the measurement of time … to have a useful meaning in many daily activities".



The 12th century Jayrun Water Clock

"The effect of the reduction in the variance of time measurement was felt everywhere", Allen writes. **Mechanical time opened up entirely new categories of economic organisation that had until then been not just impossible, but unimaginable.** Mechanical time allowed trade and exchange to be synchronised across great distances. It allowed for production and transport to be coordinated. It allowed for the day to be structured, for work to be compensated according to the amount of time worked — and for workers to know that they were being compensated fairly. Both employers and employees could look at a standard, independent instrument to verify that a contract had been performed.

Complete and incomplete smart contracts

Oliver Williamson and Ronald Coase (who was also an economics Nobel prize winner, in 1991) put contracts at the heart of economic and business organisation. Contracts are at the centre of institutional cryptoeconomics. It is here that blockchains have the most revolutionary implications.

Smart contracts on the blockchain allows for contractual agreements to be automatically, autonomously, and securely executed. Smart contracts can eliminate an entire class of work that currently maintains, enforces and confirms that contracts are executed — accountants, auditors, lawyers, and indeed much of the legal system.

But the smart contracts are limited by what can be specified in the algorithm. Economists have focused on the distinction between complete and incomplete contracts.

A **complete contract** specifies what is to occur under every possible contingency. An **incomplete contract** allows the terms of the contract to be renegotiated in the case of unexpected events. Incomplete contracts provide one explanation for why some exchanges take place in firms, and

why others take place in markets, and provides a further guide to questions surrounding vertical integration and the size of the firm.

Complete contracts are impossible to execute, while incomplete contracts are expensive. The blockchain, though smart contracts, lowers the information costs and transactions costs associated with many incomplete contracts and so expands the scale and scope of economic activity that can be undertaken. It allows markets to operate where before only large firms could operate, and it allows business and markets to operate where before only government could operate.

The precise details of how and when this will occur is a challenge and a problem for entrepreneurs to resolve. Currently, **oracles** provide a link between the algorithmic world of the blockchain and the real world, trusted entities that convert information into data that can be processed by a smart contract.

The real gains to be made in the blockchain revolution, we suggest, are in developing better and more powerful oracles — converting incomplete contracts to contracts that are sufficiently complete to be written algorithmically and executed on the blockchain.

The merchant revolution of the middle ages was made possible by the development of merchant courts — effectively trusted oracles — that allowed traders to enforce agreements privately. For blockchain, that revolution seems yet to come.

Whither government?

The blockchain economy puts pressure on government processes in a whole host of ways, from taxation, to regulation, to service delivery.

Investigating these changes is an ongoing project of ours. But consider, for instance, how we regulate banks.

Prudential controls have evolved to ensure the safety and soundness of financial institutions that interact with the public. Typically these controls (for example, liquidity and capital requirements) have been justified by the fact that depositors and shareholders are unable to observe the bank's ledger. The depositors and shareholders are unable to discipline the firm and its management.

Bank runs occur when depositors discover (or simply imagine) that their bank might not be able to cover their deposits, and they rush to withdraw their money.

One possible application of the blockchain would allow depositors and shareholders to continuously monitor the bank's reserves and lendings, substantially eliminating the information asymmetries between them and the bank management.

In this world, market discipline would be possible. Public trust in the immutability of the blockchain would ensure no false bank runs occurred. The role of the regulator might be limited to certifying the blockchain was correctly and securely structured.

A more far reaching application would be a **cryptobank** — an autonomous blockchain application that borrows short and lends long, perhaps matching borrowers with lenders directly. A cryptobank structured algorithmically by smart contracts would have the same transparency properties as the bank with a public blockchain ledger but with other features that might completely neglect the need for regulators. For example, **a cryptobank could be self-liquidating**. At the moment the cryptobank began trading while insolvent, the underlying assets would be automatically disbursed to shareholders and depositors.

It is unclear what regulatory role government should have in this world.

Tyler Cowen and Alex Tabarrok have argued that much government regulation appears to be designed to resolve asymmetric information problems — problems that, in a world of information ubiquity, often do not exist any more. Blockchain applications significantly increase this information ubiquity, and make that information more transparent, permanent, and accessible.

Blockchains have their uses in what is being called **'regtech'** — the application of technology to the traditional regulatory functions of auditing, compliance, and market surveillance. And we ought not to dismiss the possibility that there will be new economic problems that demand new consumer protections or market controls in the blockchain world.

Nevertheless, the restructuring and recreation of basic economic forms like banks will put pressure not just on how regulation is enforced, but what the regulation should do.

Whither Big Business?

The implications for big business are likely to be just as profound. Business size is often driven by the need to cover the costs of business hierarchy — in turn due to incomplete contracts and technological necessity of large scale financial investment. That business model has meant that shareholder capitalism is the dominant form of business organisation. The ability to write more complete contracts on the blockchain means that entrepreneurs and innovators will be able to maintain ownership and control of their human capital and profit at the same time. The nexus between operating a successful business and access to financial capital has been weakening over time, but now might even be broken. **The age of *human capitalism* is dawning.**

Entrepreneurs will be able to write a valuable app and release it into the "wild" ready to be employed by anyone and everyone who needs that functionality. The entrepreneur in turn simply observe micro-payments accumulating in their wallet. A designer could release their design into the "wild" and final consumers could download that design to their 3D printer and have the product

almost immediately. This business model could see more (localised) manufacturing occur in Australia than at present.

The ability of consumers to interact directly with producers or designers will limit the role that middlemen play in the economy. Logistics firms, however, will continue to prosper, but the advent of driverless transportation will see disruption to industry too.

Bear in mind, any disruption of business will also disrupt the company tax base. **It may become difficult for government to tax business at all** — so we might see greater pressure on sales (consumption) taxes and even poll taxes.

Conclusion

The blockchain and associated technological changes will massively disrupt current economic conditions. The industrial revolution ushered in a world where business models were predicated on hierarchy and financial capitalism. The blockchain revolution will see an economy dominated by human capitalism and greater individual autonomy.

How that unfolds is unclear at present. Entrepreneurs and innovators will resolve uncertainty, as always, through a process of trial and error. No doubt great fortunes will be made and lost before we know exactly how this disruption will unfold.

Our contribution is that we have a clear understanding of a model that can be deployed to provide clarity to the disruption as and when it occurs.

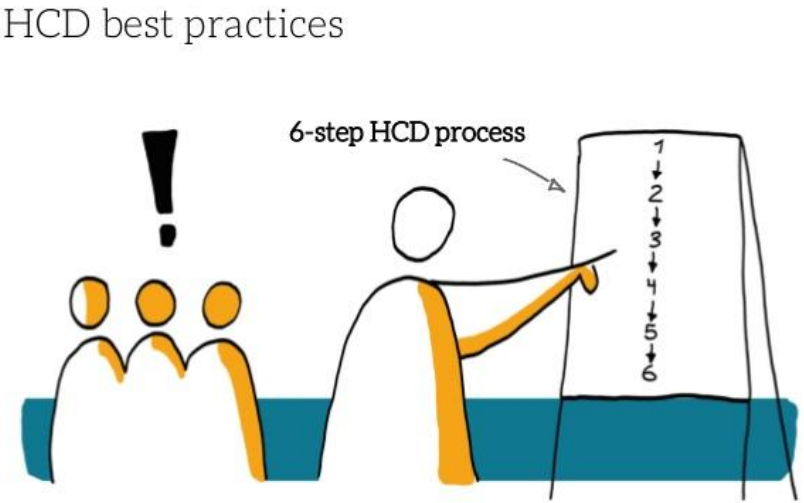
- Blockchain
- Cryptoeconomics
- Cryptocurrency
- Economics
- Institutions

AABE Hackathon

Innovative Solutions for Today's Energy Challenges

6 steps in Human Centered Design Process

- Identify
- Immerse
- Reframe
- Ideate
- Build
- Test



Identify

Goal: Defining the targeted problem space you will tackle.

Outputs: 4-5 broad questions that define the problem spaces to research.

Key Questions:

- What are the facts, assumptions, and problem space you can identify about the larger problem?
- What local organizations and mentors can you work with to help tackle this challenge?
- What are 2-3 initial How Can We's that will help focus research in your problem spaces?

Immerse

Goal: Empathize with end-users (stakeholders) and uncover insights to deeply understand your problem spaces.

Outputs: Empathetic stories of stakeholders. 2-3 key insights along with visual representation.

Key Questions:

- What are interesting facts, stories, themes and existing solutions from your secondary research that you are excited to explore further?
- Who are stakeholders within your problem spaces? Organizations? Places?
- What are 2-3 key insights along with visuals to explain those insights?

Reframe

Goal: Define the change you want to make in the world and what your solutions needs to accomplish to get there.

Outputs: 3-4 Design Goals defining desired solutions qualities.

Key Questions:

- Based off of your teams research and insights, what qualities does your solution need for it to be effective? (These are your Design Goals)
- What end results will indicate that future solutions impact your users' lives? (These are your measures of success)

Ideate

Goal: Generate a variety of ways that make change and explore many alternative solutions.

Outputs: List of 10+ different ideas. 2-4 well-considered concepts..

Key Questions:

- What are some of your wildest ideas? Safest ideas? Easy to implement ideas? Difficult to implement ideas?
- What are themes or categories that your different ideas begin to explore?
- Based on alignment with your design goals and measures of success, what 2-4 concepts are you going to build?

Build

Goal: Make a variety of tangible prototypes to communicate your ideas.

Outputs: At least 2 built prototypes of every concept you're moving forward with for user testing and feedback. A list of important questions to learn about each concept..

Key Questions:

- What are at least 2 different ways you are prototyping each concept?
- What are the simplest ways that you can prototype your concepts to quickly get user feedback?
- What are the important questions you have about each of your concepts that you need to learn as you build your prototypes?

Test

Goal: Get feedback to uncover insights and develop next steps to improve a solution.

Outputs: 4-5 user/expert quotes about your solution. 2-3 insights to inform next steps.

Key Questions:

- How are you ensuring that your tests will help you answer the important questions you have for each concept?
- What quotes and stories from users and experts stood out to you during testing?
- What insights from testing are directing further research and ideation?