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Journal

The Capco Institute Journal of Financial Transformation

A new world order

Colliding worlds

'No meal without rice': industry alignment and infrastructure in Chinese Bitcoin mining

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Journal

Welcome to the 62nd edition of the Capco Journal of Financial Transformation, the second to be published in partnership with King's College London, a world-renowned leader in education and research.

This year marks the Journal's 25th anniversary and the beginning of **Capco30**, our strategic vision as we build towards Capco's landmark 30th anniversary.

At the heart of Capco30 is The Expert Advantage: our commitment to be the trusted partner clients turn to when the stakes are highest. We are proud to have built an exceptional business by obsessing about our deep expertise, our strong client relationships, our innovative culture and our reputation for impact.

The Journal has embodied that ambition since its launch in 2001. Over the past quarter century, it has brought together leading academics and industry practitioners – including Nobel laureates, international regulators and board members of major institutions – to examine the forces shaping financial services and the wider global economy. We are equally proud to see Capco experts sharing their perspectives alongside such distinguished contributors.

As Professor Crawford Spence, our editor from King's College, observes in his introduction, this edition might aptly have been titled 'how to survive and thrive in turbulent times'.

After decades of globalization, firms are both refocusing on local market shifts and new forms of cross-border collaboration. Technology is driving integration as trade barriers rise; financial innovation is accelerating amid monetary realignment and volatile geopolitics; and the green transition is redrawing both energy markets and fiscal priorities.

Edition 62 focuses on the **new world order** emerging from these shifts – and how leaders across financial services and energy are rethinking established assumptions, navigating new risks and identifying opportunities for growth.

The coming decade could bring one of the most consequential reconfigurations of global business and economic systems in generations.

This environment reinforces the importance of expertise, judgement and the ability to turn insight into action. At Capco, we help clients connect vision models and strengthening resilience to reimagining customer experiences and the future of work.

We bring together industry depth, technology and data capabilities, and disciplined execution to help clients navigate the moments that matter most with confidence.

The Journal is one expression of that Expert Advantage: convening leading perspectives, challenging established thinking and helping shape the agendas that will define the future of our industries.

I hope you will find the articles in this edition both thought-provoking and valuable for informing your organization's future vision and strategic decisions.

My sincere thanks and appreciation to our contributors, readers and clients.

Annie Rowland, Capco CEO

2026, Edition 62

Editor's note

We could equally have labelled this volume of the Journal of Financial Transformation 'how to survive and thrive in turbulent times', given that each of the articles effectively attempts to tackle this issue in their own unique way. Times are indeed turbulent. Recent months and years have borne witness to increased military conflict, heightened economic shocks and the emergence of new political forces.

These disruptions are often captured in popular discourse by reference to, variously, the decline of the rules based international order, the rise of authoritarianism and the re-emergence of nationalism and protectionism as challenges to globalization. While putting clear conceptual parameters around what is a very unsettled geopolitical period is difficult, there is at the very least little doubt that the world is changing and that a new order is emerging. To paraphrase an old political aphorism: the old is dying and the new is struggling to be born.

This geopolitical reshuffling is the backdrop to the current issue of the Journal. Contributors were asked to think about how financial services and energy might respond to, and indeed themselves help reshape, the new global order that is emerging. What they have presented here can be grouped into four conceptual clusters, each of which makes up a distinct sub-theme in this issue of the journal: colliding worlds; monetary risks; strategic pivots; and private markets.

The first group of articles we refer to here as colliding worlds. The worlds that collide here specifically are those of finance and energy. Each of these forces us to zoom out from financial transactions and investments and think about the wider environmental and material basis for these. For example, Ragland's fascinating look at the arms race for computing power shows how the rapid expansion of data centers is at odds with the way in which existing energy infrastructure is built. Those who will be successful in rolling out advanced computing power are those who will be able to finance and build out alternative energy infrastructure at the same time.

This has strong parallels with Xu and Preda's article looking at the infrastructure of bitcoin mining, which demonstrates in some detail how supposedly digital assets have heavy materiality in terms of both the physical infrastructure that supports them and the energy consumption that goes into their mining and processing. Finally, Savignon takes the energy transition head on by exploring the mechanics and possibilities of carbon credits in Brazil, a country which is characterised by a dominance of renewables in its energy mix. Showing real heterogeneity in how carbon credits are deployed in different sectors in Brazil, this article concludes by outlining how those who are able to integrate thinking around finance, data and energy will be able benefit from and contribute to the energy transition in the Brazilian market.

Monetary risks refer to the various ways in which currencies are embroiled with risk at both the national and transnational levels. As the fundamental means via which deals are transacted, it is perhaps no surprise that we find money, in its various guises, to have so many political inflections. Cryptoassets are often heralded as some kind of safe haven (‘digital gold’) during times of economic and political turmoil and there are many central banks across the globe who are now pursuing digital currency projects of their own. These have significantly lagged the development of private crypto initiatives. One of the reasons for this might be the perceived financial crime risk that is associated with digital currencies in general, something which Tjeransen’s article outlines in detail.

Fiat currencies are also deeply imbricated in geopolitical factors. This is the subject of Hou et al’s article which draws attention to the ways in which currency risk premia are associated with trade imbalances between nations. Such factors are of increasing importance to, not only forex traders, but any organization engaging in currency hedging. Finally, nowhere is the importance of currency to geopolitics more evident than in Zayim’s article looking at how central banks engage in currency swaps with other central banks. Focusing on both China and the US, Zayim shows how each has sought to build up spheres of influence with different counterparties as part of larger attempts to accrue power and minimize geopolitical risk for themselves.

Our third conceptual ‘bucket’ looks at how individual organizations respond to geopolitical shifts. In other words, these articles look at the various strategic pivots that organizations make in order survive and thrive in turbulent times. These strategic pivots can take different forms depending on the geography and industry in question. For example, Schnyder shows how banks in East Central Europe can mitigate risk in response to rising anti-FDI policies in that region. In Scriven’s article the author shows how software delivery needs to be reconfigured in order to overcome increasing regulatory divergence and export controls.

In times of geopolitical uncertainty, capital markets can become less efficient in allocating capital and so firms have to focus more on their internal efficiencies, which is what Gkikopoulos and Stathopoulos illustrate in their article exploring the relationship between firms and banks; such relationships have implications for tax planning and productivity. Political turbulence also impacts hiring strategies, which Nguyen and Sila demonstrate in relation to corporate hiring practices during times of election uncertainty. Finally, Confalone makes a strong case for a strategic pivot towards developing ‘enterprise intelligence’ in the age of AI, a shift which has governance implications for financial services organizations.

The final sub-theme of the issue reflects an ongoing interest that we have had in private markets. The shift from public to private markets is one of the big secular shifts of modern finance, which was dealt with explicitly in issue 61. In this issue, we build on this with two further articles. One of these, by Phalippou, tackles the shift of private equity towards retail investors, outlining the potential risks in selling private equity products that were designed with institutional investors in mind to a less informed and less powerful constituency. Preda and Chen’s article pursues another tack, showing how venture capital funding in Asia and elsewhere has to be cognisant of surrounding government policy imperatives if it is to be successful.

Taken together, these articles argue that financial services are not simply being buffeted by geopolitical change. They are becoming one of the arenas in which that change is negotiated. Through payment systems, liquidity backstops, energy and computing infrastructure, corporate strategy and the evolving boundary between public and private markets, we can see how geopolitical forces manifest themselves and adapt to existing institutional constraints and imperatives.

Professor Crawford Spence
King’s College London

‘No meal without rice’:

industry alignment and infrastructure in Chinese bitcoin mining

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Abstract

This paper examines the infrastructure of bitcoin mining, the proverbial ‘rice’ that anchors the production of crypto assets. While debates about bitcoin have focused on value, speculation, and energy consumption, far less attention has been paid to the material infrastructures that make mining possible. Drawing on interviews with early miners, follow-up interviews with Chinese miners who later migrated to the United States, and a two-week ethnographic study of site construction in Ohio, we analyze how mining infrastructure has been built, reorganized, and industrialized over the past fifteen years. We argue that this evolution has been shaped by four forces: geopolitical realignments, opportunity-seeking across mining and adjacent sectors (especially energy and hardware), intensifying competition for speed and efficiency, and the consolidation of mining into a capital-intensive industrial sector. Together, these dynamics have transformed mining from a flexible, experimental activity into an increasingly corporatized form of industrial production. The paper shifts attention from cryptocurrencies as financial objects to the infrastructures that sustain them, showing how mining is now organized around the industrial constraints of construction, energy, logistics, and capital coordination. In doing so, it foregrounds the persistent temporal tension between intersecting material markets, speculative expectations of rapid returns, and the slow, costly work of building and sustaining durable infrastructural systems.

1. Introduction

There is an old Chinese proverb, ‘no meal without rice’: even the cleverest cook cannot make a meal without rice – the modest rice anchors the flavors of most meals. Similarly, not even the cleverest businessperson can mint and trade crypto assets without the infrastructure provided by data centers, an infrastructure that supports a variety of blockchains. One of the best-known chains is the bitcoin blockchain, anchored in a network of data centers that enable mining operations – that is, competitively handling cryptographic problems that, if successfully and timely solved, will lead to a new bitcoin being minted. This network provides the ‘rice’ to the ‘meals’ coveted by institutions and individuals alike. While the value and nature of bitcoin have been subject to much academic debate, less attention has been paid to the ‘rice’, the mining network that supports bitcoin. When this has happened, conversations have focused mostly on the energy consumption required by proof of work (PoW), the main protocol of bitcoin. How has this infrastructure evolved over time and which factors have influenced this evolution? As many a cook knows, there are many flavors of rice. What are the flavors of the bitcoin ‘rice’?

In this paper, we argue that the infrastructure of bitcoin mining has evolved significantly over the past fifteen years or so, primarily under the influence of the following factors: (1) geopolitical realignments that created barriers but also opportunities; (2) opportunity searches within both bitcoin mining and within adjacent industries, primarily the energy sector and hardware manufacturing; (3) a competition for speed not dissimilar from what we have observed in high frequency trading; and (4) consolidation of bitcoin mining as an industrial sector, characterized by scaling up, technological innovation, and response to profitability pressures. As bitcoin mining has become more of a standard industrial sector, we see it confronted with familiar issues, such as project management, timely delivery, search for cheap energy sources, and balancing financial with manufacturing constraints.

We draw on interview data with miners active in the early phases of the industry, as well as with miners who were active in Asian mining but later migrated to the U.S. We build on a two-week ethnographic study shadowing Chinese miners as they built, designed, and reconfigured mining sites in Ohio. We show how technological infrastructures have been reorganized over time and how mining has become an increasingly capital-intensive and corporatized activity. We show that mining is no longer a mere technical activity, but an infrastructure-heavy form of asset production that increasingly resembles hardware, energy, data-center, and industrial real estate projects. For financial practitioners, the case illustrates the gap produced by standard valuation models that systematically underestimate infrastructural and material time and shows why crypto finance now operates not only as a market for assets, but as a practice of managing multiple, intersecting material and financial timelines.

2. The role of Chinese miners: configuring the infrastructural work of crypto mining

In the early stages, for a short period of time, bitcoin mining was relatively diffuse, in the sense that individuals owning a working laptop could participate in this process too. However, this changed rapidly around 2010, with the switch from CPU (central processing units) to GPU (graphic processing units). Mining activities became heavily concentrated in mainland China: by 2015, China's share of bitcoin mining was already 50%, while the U.S. share declined to 10% (see Figure 1). In the mid-2010s, the regulatory environment in the U.S. was favorable to miners – for instance, in 2014 the IRS started treating virtual currency as property (meaning that miners had to declare income from mining), while miners were not treated as a money service providers (meaning that they were not subject to the respective regulations). The Chinese regulatory environment was largely indifferent in the 2010s, allowing Chinese miners to exploit some competitive advantages provided by access to cheap electricity and to already existing manufacturing ecosystems. Starting in 2013, Chinese miners began the rapid scaling of computational infrastructure, with the introduction of ASIC miners (application-specific integrated circuits), specifically designed for bitcoin mining. According to the Cambridge Bitcoin Electricity Consumption index, by 2019, China accounted for approximately 74% of the global bitcoin hashrate, effectively functioning as the infrastructural backbone of what was often represented as a decentralized system.[1]

This concentration was not accidental. It reflected the convergence of several material conditions: proximity to ASIC manufacturing, improvement of ASIC technology, access to cheap power, the availability of buildable infrastructure, and a regulatory environment that, for a long time,

[1] https://ccaf.io/cbnsi/cbeci/mining_map

remained ambiguous or indifferent, rather than explicitly prohibitive. Together, these conditions allowed China to host the durational and energy-intensive work required to sustain the bitcoin network at scale. These spatial alignments expose how 'borderless', decentralized digital finance is nonetheless grounded in place-specific material conditions.

This infrastructural centrality came to an abrupt end when the Chinese government moved to shut down domestic crypto-mining operations in 2021. China's share of the global hashrate fell dramatically following the regulatory crackdown, dropping from dominant levels to a much smaller fraction within a short period of time. Despite this, China's infrastructural contribution remains significant to this day, pointing to mining having moved under the radar. Estimates are that, in 2024, China took between 14-21% of the global hashrate.[2] Even as more mining rigs were shutting down in Xinjiang province, Chinese mining pools continue to be among the largest contributors to the global hashrate.[3,4] At the same time, the majority of specialized ASIC mining rigs are designed and manufactured by Chinese companies, embedding Chinese hardware and operational influence deeply in the global network, underscoring the ongoing material presence of Chinese actors and technologies in the industry.

After the 2021 regulatory ban, geopolitical reconfigurations forced large parts of the industry to migrate, most notably to the U.S. [Onat et al. (2024)], but also to Kazakhstan and to Russia. Kazakhstan achieved a share of 18% of the global hashrate in 2021. Paradoxically, the war in Ukraine has not prevented an increase in Russia's share of bitcoin mining from 11 to 16%, and bitcoin has been legalized in Russia in 2024.[5] It is notable that, among these developments, Europe's share in bitcoin mining has been reduced to 4%, while the U.S. share is almost back to where it was in 2009 (40% today versus 50% in 2009). We need to insert here the caveat that the use of VPNs makes accurate estimates of some countries' share of the hashrate difficult (notably China's and Russia's).

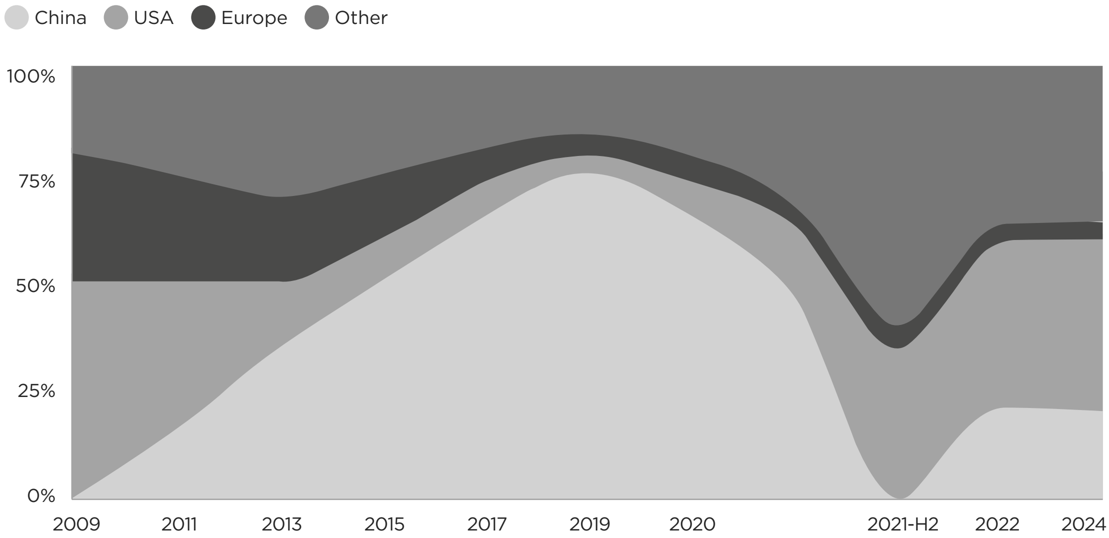
Overall, the redistribution of mining capacity that followed did not simply represent a geographic relocation of computational hashing. It marked a shift in the geopolitical regime of mining, as operations were forced to be reorganized across a different assemblage of energy markets, regulatory environments, infrastructural forms, and capital constraints. Yet this mobility is constrained by the physicality of equipment and energy systems, and more so by different temporal regimes and construction timelines. Mining, which emerged as a distinct economic sector in the late 2010s, has not been developed in isolation from other sectors, most notably the energy and the hardware ones. This has forced miners and other adjacent actors into opportunistic searches for profit generation, to which we turn in the next section.

3. When machines follow rivers: opportunistic searches for profit generation

Cheap electricity and stable power sources are the primary conditions supporting bitcoin mining. Mining relies on getting machines online and plugged into the network to start contributing computing power to process information into blocks. Whenever a block is successfully mined,

2 https://www.coindesk.com/markets/2025/11/24/china-returns-as-third-largest-bitcoin-mining-hub-with-a-14-share-reuters?utm_source=chatgpt.com
3 https://www.coindesk.com/markets/2025/12/15/bitcoin-hashrate-sees-sharpest-post-halving-drop-since-2024-amid-china-mining-machine-shutdowns
4 A crypto-mining pool is a collaboration of individual cryptocurrency miners who combine and aggregate their computational power (hashrate) over a network to increase their collective chances of successfully mining a block and earning rewards with others. It functions like a cooperative 'super-miner' union to provide more frequent and predictable outcomes.
5 https://atlas21.com/the-growth-of-bitcoin-mining-in-russia-an-overview-of-the-sector

Figure 1: The geographic distribution of the bitcoin hashrate over time



(This figure has been produced using Opus 4.5. Data sources are at the end of this article.)

the miner who wins the competition receives the block reward in bitcoin [Lo and Medda (2019)]. In the 2010s, the network was not yet highly competitive, and the intensity of competition was much lower than today. Yet, while miners had to engage in competitions for obtaining the bitcoin reward, they also had to pay attention to the cost of their operations, a significant part of which was given by electricity prices.

Bitcoin miners had always had to look for cheap electricity in order to sustain profitability. This partly explains why in the early days (2010 to 2021) their activities were located in mainland China, where they had access to comparatively cheap coal and hydroelectric power in inner Mongolia, Szechuan, and Yunnan, respectively. Moreover, they could benefit from the fact that not all hydroelectric power plants were connected to the national grid: this enabled miners to negotiate preferential, private electricity rates that deviated from the electricity prices charged in the national grid. On their side, power plant operators saw the arrival of bitcoin miners as an opportunity to recoup their investment in a shorter period of time:

"In the old days, if you built a water dam, it took eight years to repay your investment, and now if we built a crypto-asset mining center next to it, it could take half of what it took to return the investment" – bitcoin miner.

Seen from the perspective of a hydroelectric dam operator, having a crypto-asset mining center next to it and supplying electricity to such a mining center means that electricity could be converted into revenue far faster than through the conventional grid. In China, it takes one to three years to build a dam, depending on scale, and recouping the investment through selling electricity to the grid typically takes around eight years. By contrast, once mining machines are installed and brought online, returns can begin almost immediately, and the time to recoup the investment is halved. Miners effectively aligned two markets and, in doing so, altered the temporal structure of returns.

Szechuan's geography made this alignment especially viable. The province is rich in water resources and mountainous terrain, and the climate is relatively cool, often eliminating the need for elaborate cooling systems (improving the efficiency of mining rigs). Electricity generated by small and medium hydropower plants (not all connected to the national grid) could thus be directly translated into hashing capacity. Hydropower dams rely on gravitational energy, spinning turbines to generate electricity; bitcoin mining, in turn, converts this electricity into hashing power and into bitcoin.

Setting up a mining center means purchasing ASIC machines (manufactured in China and provided by a Chinese supplier), installing containerized mining units, each capable of hosting up to 300 machines, and installing cooling systems (also provided by a Chinese manufacturer). In this sense, bitcoin mining as an industry cannot be seen in isolation from the hardware manufacturing and energy industries. Opportunistic searches for profit were not limited to actors from the energy sector; hardware manufacturers, on their side, saw the emergence of bitcoin mining too as an opportunity to generate new profits. Oral accounts point to adjacent industries as entering mining as a way of increasing sales but also of generating new profits:

“In the early days, a lot of the miners [who invest in owning ASICs] actually did not understand the value of bitcoin, but a lot of the infrastructure builders or hardware producers did invest in it. They, for example, are socket makers, plug sellers. They saw that people were busy setting up machines and data centers and ordering large quantities of sockets and plugs from them. They would send their sons to ask what these people were doing, and that’s how they found their way into bitcoin mining. This was their quick way to pivot from hardware provider to crypto-asset mining” – bitcoin miner.

Many of the early participants in bitcoin mining did not come from finance or speculative trading, but from hardware supply, electrical equipment, and infrastructure-related businesses. They were already embedded in the same material world of sockets, cables, power equipment, cooling, and construction. For these actors, entering mining was not initially a move into a financial market, but an extension of existing hardware and infrastructure trading to a new application. Bitcoin mining successfully aligned a number of players that were in search of profit opportunities.

4. The emergence of a migratory industry

As mining operations are tightly coupled to energy infrastructures, disruptions in power supply (e.g., breakdowns, price volatility, unstable supply) introduce further pressures on operators. Miners were often notified in advance of planned outages or seasonal adjustments in electricity provision. Their response has been threefold: migrate in search of cheaper power sources; build your own power sources or secure preferential contracts; and innovate technologically. Let’s look first at migration.

Notices of power disruptions trigger a cascade of logistical actions: machine owners must rapidly secure alternative hosting arrangements, negotiate access to other data centers, and physically relocate equipment in order to preserve continuity of operation. Here, the work of mining extends beyond computation to include the coordination of multiple material markets – hardware, energy, hosting, and logistics, each governed by different rhythms and constraints.

“When there is an electricity shortage on one site, you can see miners will arrange vehicles and carts of horse carriages to carry their machines to another site to host. As this is usually a remote mountain area, you can see there are also traffic jams in these small rural passages” – mining site manager and mining machine technician.

When the Chinese government started cracking down on bitcoin mining, many miners migrated to Kazakhstan, which was attractive not only because of geographical proximity and territorial size (about as large as Western Europe), but also because of cheap power resources. However, migration itself is costly: one could perhaps load mining rigs on horse drawn carts when a mine leaves a remote mountain location but, as operations grow, so does the cost of migrating them, and horse-drawn carts become impractical. An alternative to migration is to build one's own power plant. Firms may collaborate with energy companies to secure remote locations with existing power supplies and reconfigure them into higher-voltage sites, or they may invest in building and operating their own power infrastructure, including hydropower facilities, nuclear plants, wind farms, or solar installations. These plans involve not only substantial upfront capital investment and long-term commitments, shaping both operational flexibility and financial risk, but also the specialized expertise of energy generation and land acquisition associated with proximity to natural resources.

A third way in which bitcoin miners have addressed efficiency pressures is technological innovation. Owning an ASIC mining rig entails a substantial upfront investment, with prices varying according to computing power and energy efficiency. Newer generations of machines offer higher hashrates and improved thermal performance, enabling them to solve cryptographic puzzles more efficiently while reducing the risk of overheating and forced shutdowns. Yet the economic value of such machines is inseparable from their continuous operation. Mining revenue is generated only when machines remain online; any interruption immediately halts income generation, while the hardware continues to age and depreciate. The drive to improve efficiency has contributed to a high rate of technological obsolescence, with new machines being brought to the market every two to four years. Usually, spatial migration in search of cheaper energy sources has paired with technological migration to improved models:

"You can see a lot of machines were just thrown away and piling up on the site, which got abandoned. When the ASIC machines were too old, they normally did not provide any hashrate. These machines are not worth anything other than just broken bronze and wasted iron" – mining site manager.

The above quote indicates a distinctive regime in which profitability depends on continuous calculation, which depends on sustained uptime across extended durations. Time, in this context, is not something to be accelerated or deferred, but something that must be continuously endured and maintained. Periods of downtime are doubly costly: they represent both an immediate loss of revenue and an irreversible consumption of the machine's productive lifespan.

Mining requires technological investment on a scale that becomes clearer when miners talk about specific generations of ASIC machines. Earlier models such as the Antminer S9 released in 2016, which produces around 13–14 TH/s, were once widely used but are now effectively obsolete and often worth little more than scrap metal.[6] By contrast, newer generations such as the Antminer S17 (around 50–60 TH/s), which was released in 2019, and especially the S19 series (often exceeding 95–110 TH/s) released in late 2020 represent a completely different level of capital investment. At the time of our fieldwork, a single S17 machine could cost tens of thousands of RMB (U.S.$1,600 to over U.S.$2,500 per unit), depending on market conditions and availability.

6 The Antminer S9, manufactured by Bitmain, was once one of the most widely-used ASIC miners for bitcoin and other SHA-256–based cryptocurrencies. As the first mass-market miner to adopt 16nm chips, it set an industry standard and dominated mining operations for a period. However, due to its relatively low hashrate and high electricity consumption by current standards, it is now widely regarded as economically obsolete under most contemporary power cost conditions.

For a container hosting two to three hundred machines, the hardware investment alone therefore easily runs into several million RMB. The latest models provided by Antminer are S21 and the S21XP Hydro, launched in 2025, which uses water cooling instead of air cooling. Today, the market is dominated by three large machine providers, namely Bitmain, Canaan, and MicroBT, with a fourth, Bitdeer, as an emerging competitor. All of them are Chinese companies.

As the network continuously upgrades to faster and more efficient ASICs, miners are forced to reinvest in new machines simply to remain competitive. Machines that fall below a baseline level of hashrate effectively drop out of the market: they can no longer ‘do work’ and therefore no longer produce value. In this sense, miners are not only coordinating across sites and infrastructures, but also across hardware generations, synchronizing their operations to the shifting temporal pace of the network itself.

5. The competition for speed

In the mid-2010s, miners had to pay attention primarily to infrastructural construction, hardware installation, and project delivery. Building a mining site resembled other industrial projects. ASIC machines could be ordered from manufacturers in China, cooling systems did not need to be especially sophisticated in mountain areas, and much of the work consisted of wiring, installation, and basic site preparation. Mining, at this point, was organized in the same temporal framework as hardware retail and infrastructure building, one oriented toward completion, installation, and gradual payback rather than rapid financial speculation. However, participation in mining also gradually exposed these actors to a different temporal regime, namely that of financial speculation. In the beginning, many miners did not treat bitcoin as a speculative asset at all.

“In the early days, as these miners did not see the value of these crypto assets, they would sell their bitcoins immediately to pay for electricity, and you can see that the bitcoin price will go down for a bit, because there would be a lot of sales going on.”

Miners were largely operating according to cash-flow constraints, seeing bitcoin simply as a way to cover operating costs and repay electricity bills. They were not yet coordinating their actions with the speculative cycles of the crypto market, nor were they arbitraging between crypto and fiat. Only later did some miners begin to learn to operate within financial temporalities, holding coins, lending them out, or staking them to market makers who needed inventory to provide liquidity [Preda et al. (2023)]. In doing so, they gradually shifted from a purely infrastructural time horizon to one that also incorporated financial cycles and speculative expectations.

The reorientation to financial cycles increased competitiveness among miners and pressure to seek more efficient mining machines. These pressures were magnified by bitcoin’s own halving cycles, which reduces the reward for miners every four years (or 210,000 blocks). This made miners compete for speed to become operational within set profitability windows:

“There is still a window to enter the bitcoin mining market in May or June this year, as the site will take more than three months before the next halving cycle happens. When the next halving cycle arrives, it will be much more difficult to mine bitcoins, as the building of the mining site has become increasingly costly, and it will no longer be profitable.”

The above excerpt is from a financial practitioner who continued to pitch bitcoin mining to institutional investors in 2022, at a time when entry costs were already high [Delgado-Mohatar et al. (2019)]. He relied heavily on financial models to explain the opportunity to investors, projecting cyclical returns and long-term trends in bitcoin's valuation. The competition for speed, reminiscent of high-frequency trading, requires in high rate of technological innovation (new mining rigs every two to four years, more efficient cooling, race to complete data centers) has also impacted the attempts to attract institutional capital.

6. Scaling up across geopolitical infrastructures

The factors discussed above – geopolitical pressures, migration in chasing efficiencies, interest alignment with the energy and hardware manufacturing sectors – have led over the course of the past decade to scaling up and consolidating mining operations. However, it did not necessarily result in the expected increased efficiencies and profitability. Scaling up brought its own challenges.

Following the 2021 mining ban in China, many Chinese miners began migrating to the U.S., particularly to areas around Detroit, where large tracts of available industrial land and high-voltage infrastructure seemed to offer favorable conditions for building large-scale data centers. Yet, the coordination required in this new setting proved far more demanding compared with their previous situation. As mining moved to the U.S. and became increasingly industrialized, infrastructural conditions resulted in a concentration of power among large operators, who had the capacity to secure energy contracts, deploy containerized data centers, and absorb the delays and risks of construction. Mining was no longer a small-scale entrepreneurial or hobbyist activity. It now required substantial capital, long planning horizons, and the ability to survive long periods without returns.

> *"However sophisticated financial models, valuation techniques or projective expectations may be, speculative projects cannot escape the slow, costly and materially enforced temporality of infrastructure.*

This shift became especially visible in the fieldwork with a group of Chinese financial practitioners who attempted to pivot into bitcoin mining by building their own site in the U.S. Coming from finance and investment backgrounds, they approached mining with strong expectations of speed and return. The project lead and site manager in the team had previous experience in mining. Yet, they quickly found themselves entangled in a web of slow, fragmented, and interdependent infrastructural timelines, with waiting times steadily accumulating.

"The main investors have arrived at the site that we would like to build, but for two weeks, we could not do anything but wait. The plan for tomorrow wasn't clear either. We may go to the office, but the main investor may want to go to the water testing lab. As I have told him many times, the water testing lab asks us to wait for results. Our boss keeps saying we should visit them tomorrow and see if we can speed things up" – fieldnote excerpt.

When the ethnographer was asking the schedule for the next day, miners showed concern that they had been put on hold to wait for the different pieces of their project to fall into place. A water test was required because the site planned to use local water for cooling, and its quality had to be verified in advance to ensure it would not clog or damage the circulation system. Until the results were confirmed, neither the cooling system nor the broader site design could be finalized.

Likewise, time was no longer something that could be accelerated through decision making or capital injection. Instead, the project became subordinated to a series of waiting periods imposed by contractors, laboratories, regulators, and landowners. The infrastructure builders faced labor shortages and would not start work until finishing previous projects. The group had to wait for a real estate agent to secure land from a landlord who owned most of the industrial property in the area and had little incentive to lease it to them. Water testing alone could take weeks.

At the same time, technical incompatibilities required extra time for configuration and further delays. All ASIC machines were manufactured in China and required different voltage standards. This meant transformers had to be installed, and new power lines extended across fields. Locally sourced transformers could take up to three months to procure. Faced with this delay, the miners considered ordering one from China and shipping it to the U.S., trading one form of waiting for another.

Energy procurement introduced yet another temporal regime. Electricity had to be secured through contracts in a volatile, market-based pricing system. Locking in a fixed price required large prepayments of millions U.S. dollars, further increasing upfront capital requirements. However, if the price was not locked in beforehand, electricity prices fluctuated seasonally, especially in summer when household consumption rose. If prices spiked, mining could instantly become unprofitable, forcing operations to shut down or scale back. In this sense, the maintenance team was not only keeping machines running but also learning to operate within the specifics of the electricity market itself.

On the one hand, miners were confronted with halving cycles, price expectations, and return models. On the other hand, they were confronted with construction time, permitting time, procurement time, and grid connection time. Project managers attempted to bridge this gap using financial models, projecting cyclical returns and long-term price trends with a linear temporality. Bitcoin training sessions for investors emphasized the halving cycle with a cyclical perspective. However, these abstract temporal projections struggled to align with the day-to-day realities of keeping a site buildable, connected, and operational.

Migrant miners arrived as speculators, expecting machines to be plugged in and producing returns quickly. In practice, however, they depended entirely on local infrastructural builders, grid connections, permits, and construction schedules. The gap between financial expectations and material timelines became a persistent source of friction. The amount of bitcoin earned per unit of hashrate had declined sharply as network difficulty increased, and returns were no longer generous enough to tolerate long delays or offline ASIC machines. With thinner margins and higher capital intensity, mistakes in timing became extremely costly. A site that came online too late or with electricity at too high a rate could easily become unviable before it ever recovered its investment.

The cyclical and projective temporality of financial models sat uneasily alongside the day-to-day work of building and operating a site: securing land, installing transformers, waiting for permits, testing water quality, and keeping machines online. The shift from abstract future-oriented valuation to the linear, interrupted, and delay-prone temporality of construction and maintenance repeatedly disrupted project timelines and investor expectations.

7. Discussion and conclusion

However sophisticated financial models, valuation techniques, or projective expectations may be, speculative projects cannot escape the slow, costly, and materially enforced temporality of infrastructure. They ultimately depend on energy systems, hardware, land, buildings, and organizational arrangements whose construction, maintenance, and amortization unfold in durational and enforced path-dependent time.

What the case of Chinese bitcoin mining shows, from early hydropower sites in Szechuan to large-scale industrial projects in the U.S., is not simply a story of technological change or regulatory displacement. It is a story about temporal misalignment across markets: between speculative financial time and infrastructural time, between cyclical valuation models and linear construction processes, and between expectations of rapid returns and the endurance required to build and sustain material systems. When resource-based markets are reorganized through financialized expectations, coordination does not fail simply because of uncertainty, but because of fundamentally different temporal orders, speculative, political, geological, and infrastructural, which cannot be fully reconciled.

Taken together, the findings show how the impatience of speculative valuation collides with the costly and time-consuming work of aligning energy, infrastructure, and hosting markets, producing a persistent tension between building durable data-center capacity and relying on temporary, opportunistic hosting arrangements to capture immediate speculative returns. Aligning expectations between finance and the intersecting markets for energy, hardware, and infrastructure is always partial and frictional, and this friction appears not as an accident but as a constitutive feature of mining at scale.

More broadly, the financial mindset of 'bridging the gap' in search of profit repeatedly underestimates the material time required to build something durable. In several cases observed in the field, this produced infrastructures that were hastily assembled, fragile, or difficult to maintain over the long term. As one miner reflected, earlier efforts to convert hydropower into faster returns already revealed this tension: while a hydropower facility might take many years to repay its investment through conventional electricity sales, mining promised much quicker returns, but only by leaning heavily on infrastructures whose own temporalities could not, in fact, be accelerated.

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