

The Money the Model Couldn't See AI, digital currency, and the blind spot in *The Limits to Growth*

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In 1972, a team of researchers at the Massachusetts Institute of Technology, led by Dennis Meadows, published a report that would become one of the most widely circulated environmental texts of the century. *The Limits to Growth*, commissioned by the Club of Rome, was translated into more than thirty languages; by frequently cited estimates, its total circulation exceeded thirty million copies. At its core was a computer model called World3 — a system of equations tracing the interaction of five global variables: population, industrial output, resource depletion, food production, and pollution.

Half a century on, the argument over the report has not died down, but it runs through a narrow channel. Were the projections accurate? Does the methodology of system dynamics hold up under scrutiny? Researchers have recalibrated the parameters, checked the model's trajectories against observed data, updated World3. A different question gets asked far less often — not about the model's accuracy, but about its construction. What, exactly, was the model built to *see*, and what could it not see at all? Because every model of the world is, before anything else, a decision about which entities exist and which fall outside the count. And the decision made in 1972 bears directly on what is unfolding in front of us: the energy and water footprint of artificial intelligence, data centers, and digital currencies.

The argument of this essay is simple in form and uncomfortable in its consequences. The framework of *The Limits to Growth* was built in such a way that it could not see money. Financial activity, credit, property relations were not part of its accounting system. Fifty years later, money has come back — in a digital phase, in the form of computing infrastructure — and it has come back as precisely the thing the framework never registered it to be: a physical load on the planet's resources. The blind spot of 1972 has become the point at which the modern economy hides its material footprint from itself.

Five variables, and what was missing among them

It is worth looking closely at the list of World3's variables. Population, industrial output, resources, food, pollution. These are physical quantities — things you can weigh, extract, burn, count in tons and in people. The model was honest in its materialism: it described the world as an exchange of matter and energy between humanity and the planet.

But that is exactly why there was no place in it for money. Credit, the financial sector, the structure of ownership, the class distribution of the product — all of this was absent from World3 not through oversight but by design. The model operated on physical flows; money is not a physical flow. And that decision, methodologically tidy in itself, had consequences that surfaced only decades later. A full treatment of the normative architecture of *The Limits to Growth* — of how the design of the World3 scenarios embedded an implicit hierarchy of development trajectories — is given in a separate study by Mikhail Finkel and Igor Kaminsky on the report and the political economy of the Cold War; here that analysis is taken as a point of departure.

The decisive move of *The Limits to Growth* was not that the report pointed to the existence of ecological constraints — that had been written about from Malthus to Ehrlich. The move was

a reformulation: the constraints were presented as a problem of governing a global system. The report posed the question of humanity's survival under conditions of resource scarcity — and left the complementary question unasked: who controls those resources, and how is the surplus from their exploitation distributed? The ecological problem was severed from the political economy of property and accumulation.

The historian James Scott described the effect of that severance, in a different context, as the characteristic work of any managerial way of seeing: rendering complex social systems into legible, governable categories is generally accomplished by obscuring conflicts over distribution. The formula "humanity consumes too much" turned resource depletion into a universal, species-level condition — instead of naming it as the consequence of particular modes of production and accumulation. The difference between per-capita ecological footprints that diverge by orders of magnitude was dissolved into a single "we."

This was not malice. Meadows and his colleagues stated plainly that their scenarios were "predictions only in the most limited sense of the word." The intellectual integrity of the modeling effort is not in question here. What is in question is something else: what a framework does once it travels beyond its makers and begins to function as an instrument for evaluating political-economic systems.

The asymmetry: what got counted, and what didn't

This is where it gets consequential. The limits framework was applied selectively — and the selectivity ran along a predictable line.

After the oil shocks of 1973 and the collapse of the Keynesian growth model, Western economies carried out what David Harvey called the "neoliberal turn": a shift from demand management and industrial growth toward financial deregulation, the deindustrialization of the core, and the primacy of financial capital. And here is the telling part: the publication of *The Limits to Growth* was not followed by any reduction in aggregate consumption in the North. The opposite happened. From the 1980s until the crisis of 2008, financial activity expanded at speed — according to the Bank for International Settlements, the notional value of over-the-counter derivatives rose from minimal levels in the early 1980s to hundreds of trillions of dollars by the mid-2000s. Financial expansion allowed the economies of the North to grow credit, assets, and paper wealth faster than the real sector grew — and thereby to sustain consumption without lowering material living standards.

The response to the discourse of limits, then, was not a contraction of material flows but their continuation through financial leverage and the deferral of part of the costs into the future. And financial expansion was granted a special status in the process. It was classified not as "real" growth — and therefore not as a load on the limits — but as the "efficient allocation of capital." A discursive maneuver placed it outside the count.

With social demands, exactly the reverse happened. The postwar social compromise in the West rested on a promise structurally parallel to the Soviet one: the continual expansion of material well-being for the majority, secured by trade unions, social-democratic parties, the welfare state, progressive taxation. Inside the limits framework, that promise turned out to be vulnerable. What had previously been framed as demands of justice — wages, social spending, the industrial catch-up development of the periphery — could now be redescribed as a factor of ecological pressure, accelerating the system's movement toward its constraints. The framework did not prescribe this use. But it made the use available: it supplied a vocabulary in

which a demand for fair distribution could be translated into the register of a threat to sustainability.

The result is an asymmetry with a predictable sign. The limits framework tightened the count where demands for fair distribution and social provision were concerned — and loosened it where financial accumulation was concerned. Karl Polanyi, back in 1944, described this as a recurring feature of the liberal economy: the construction of ostensibly universal rules whose application is systematically uneven.

The precise status of this claim matters. This is not about a proven intent, and not about a causal link. Whether such an intent stood behind the construction of World3 is a question the available evidence cannot answer; an analysis of structure can neither confirm it nor rule it out. The claim is about something else — structural compatibility: the way the framework's design, and the vocabulary it supplied, turned out to be serviceable for a particular political use. This is compatibility, not conspiracy. But it is precisely the structural character of that compatibility that calls for analysis.

The return of the repressed

Now, fifty years on, the money the model could not see is coming back. And it is coming back not as a metaphor but as kilowatt-hours and cubic meters of water.

Artificial intelligence, data centers, cryptocurrencies — this is activity that ordinary language and economic statistics alike traditionally assign to the "immaterial" pole of the economy. Information. Algorithms. Digital assets. Finance. The vocabulary itself — "the cloud," "virtual currency," "intangible assets" — suggests something weightless, unmoored from matter. It is precisely that suggestion that turns out to be false.

Computing infrastructure has a direct, measurable physical footprint along three linked dimensions: energy, water, materials.

On energy, the data are relatively solid. The International Energy Agency estimates electricity consumption by data centers at roughly 1.5 percent of the global total as of 2024 — about 415 terawatt-hours. By 2030, in the agency's central scenario, that figure doubles, reaching approximately 945 terawatt-hours: comparable to the current annual electricity consumption of Japan. In 2025, data-center demand grew by 17 percent, and the AI-focused segment by 50 percent.

Let me say up front what cannot be said, however much one might want the punch of it. It is not true that data centers already burden the environment more heavily than agriculture. They do not. As of 2024, data centers account for a little over 1 percent of global carbon dioxide emissions; agriculture — in land use, methane, freshwater consumption, pressure on biodiversity — remains a source of strain larger by an order of magnitude. Even within energy, the growth in data-center demand to 2030 is smaller than the growth from electric vehicles, from air conditioning, and certainly from industry. Anyone building an argument on a supposed "overtaking" loses it at the first check.

The force of the observation lies not in the gross share. It lies in three other things. First, the pace, and what it means. Data-center electricity consumption is growing so fast that, for the first time in the entire postwar period, overall electricity demand is beginning to outpace GDP growth. The coupling that economists treated as almost a law of nature — energy use

follows economic growth — is breaking. And it is breaking on the side of activity that the statistics file under "immaterial."

Second, local concentration. A gross share of one and a half percent conceals just how unevenly the load is distributed. In certain jurisdictions, the data-center share of electricity consumption has already become a structural quantity — single and even double digits of the regional energy balance. The planetary average is misleading here: the crisis is local, and it has already arrived at specific points, while the aggregate figure still looks modest.

Third, the scale of capital. And here the digital infrastructure connects to finance directly. The capital expenditure of just five of the largest technology companies on data centers exceeded 400 billion dollars in 2025 — more than global investment in oil and gas extraction. This is no longer a peripheral line item. It is a redirection of capital on a planetary scale — and it is directed into infrastructure that the economy still files under the heading of the "immaterial."

The water nobody counts

The energy footprint is only part of the story. The second part — water — is more poorly documented, and that fact is itself significant.

Data centers consume water in two ways. Directly, for cooling: server racks under load run hot, and evaporative cooling remains one of the cheapest ways to keep the chips from overheating. And indirectly, through the water spent on producing the electricity they consume.

A methodological correction matters here. Water and energy are not two independent dimensions that can be added up as separate terms. They are a single linkage. By available estimates, roughly 80 percent of a data center's water footprint is embedded in the electricity it uses: in the United States in 2023, data centers consumed about 66 billion liters of water directly for cooling — but nearly 800 billion liters indirectly, through the power grid. To consume electricity is to consume water. Which means that a rise in energy consumption is automatically a rise in water consumption, even if not a drop evaporates on the site itself.

The best current illustration of the direct footprint is an International Energy Agency estimate: a 100-megawatt data center consumes on the order of 2 million liters of water per day, averaged across cooling strategies. And, as with energy, the load is locally concentrated. By an estimate from researchers in Houston, the data centers of Texas alone use about 49 billion gallons of water in 2025 — with a projection of up to 399 billion gallons by 2030. The latter figure is equivalent to drawing down the level of Lake Mead, the largest reservoir in the United States, by more than sixteen feet in a year.

But the most telling thing about the water footprint is not the numbers — it is their absence. Water data are systematically worse than energy data. Corporate reporting, as a rule, does not pair water consumption with the capacity of facilities, the cooling technology, or indirect consumption through the grid. What gets published offers only a fragmentary picture.

This measurement deficit is best read not as a technical artifact but as a continuation of the same logic as 1972. Activity classified as "digital" and "immaterial" stays outside systematic environmental accounting — not because its footprint is small, but because the accounting apparatus for it has not been built. The invisibility here is reproduced not at the level of physics but at the level of categories.

Crypto as the limiting case

If data centers and AI show that the "immaterial" economy has weight, then proof-of-work cryptocurrency carries the story to its logical extreme.

Proof-of-work mining is structured so that the computational work — the expenditure of electricity — *is* the substance of the process. Competing machines run through trillions of possibilities; the winner adds a block and receives a reward. There is no good in the traditional sense here, and no service: the expenditure of energy is not a side effect of producing something else — it is itself the mechanism. This is, in its pure form, financial activity whose thermodynamic footprint reduces to nothing else.

And that is exactly why crypto dismantles the discursive division on which the asymmetry of the neoliberal turn rested — the division between the "paper" economy and the "real" one. In the 1980s, financial expansion could be placed outside the limits framework by calling it the "efficient allocation of capital," immaterial by nature. Proof-of-work makes that move impossible. What stands before us is a financial instrument whose operation is measured directly in watts. The "paper" turned out to be fully material — and measurably so.

World3 could not have registered such activity at all. There is neither a financial sector nor a computing infrastructure among the model's five variables. A mining farm would have passed through the aggregates of "industrial output" and "pollution" without a category of its own — its nature as a financial operation simply does not exist within the model. What was a methodological simplification in 1972 has become, today, a blind spot at precisely the point where the new economy is expanding its material footprint fastest.

What follows from this

Let us gather the argument. *The Limits to Growth* built an accounting framework that saw matter and did not see money. That framework was applied asymmetrically: financial accumulation was lifted out from under the ecological count, while demands for fair distribution were drawn under it. Half a century later, financialization has entered a digital phase — AI, data centers, cryptocurrency — and that phase has a physical footprint the framework is still not equipped to register.

What follows from this is not the conclusion that "AI is destroying the planet." That conclusion would be both factually inaccurate — the share is still moderate — and analytically empty. What follows is something else, less striking and more uncomfortable.

The problem is not that digital infrastructure consumes too much. The problem is that our accounting apparatus still classifies it as something that does not need to be counted. "The cloud," "virtual currency," "intangible assets" — these are not descriptions but categories of exemption from the count. They work the same way the formula "efficient allocation of capital" worked in the 1980s: they place activity on the far side of the ecological frame. The only difference is that now, behind the word "immaterial," stands infrastructure that consumes the water of lakes and energy on a national scale.

From this comes the direction worth thinking in. Not "stop AI," but rebuild the accounting framework so that financial and digital activity enters it with a category of its own, rather than dissolving into the aggregates. Make the energy-and-water footprint of computing infrastructure a subject of mandatory, standardized, public measurement — with the same rigor

applied to industry. Close the gap between what the economy calls immaterial and what physically burdens the planet.

The central lesson of *The Limits to Growth* lies not in the specific projected curves, many of which have proven surprisingly durable. The lesson is that every model of the world begins with a decision about which entities deserve to be counted. The 1972 decision placed money outside the brackets. Fifty years later, money has come back — as energy, water, metal — and presented a bill the framework never learned to read. Before arguing about the numbers, it is worth fixing the categories. Invisible does not mean weightless; it means only that we have built an optics in which it cannot be seen.

A note on sources. Energy figures are estimates from the International Energy Agency (the Energy and AI report, 2025, and Electricity 2026). Water figures are from the International Energy Agency and estimates by Lawrence Berkeley National Laboratory; the local Texas estimates are from the Houston Advanced Research Center together with the University of Houston. The financial-historical context draws on the work of David Harvey and Karl Polanyi and on data from the Bank for International Settlements.

The analysis of the normative architecture of The Limits to Growth — the section on what the model's accounting framework was able to see and what it left outside the brackets — develops the argument of the research paper: Finkel, M., & Kaminnyk, I. (2026). The Limits to Growth and Cold War Political Economy: Normative Structure in Global Systems Modeling. APSA Preprints. <https://doi.org/10.33774/apsa-2026-cj8z1-v2>