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Green Finance and the Hidden Hand of Algorithmic Planning: Debunking Market Rhetoric in the Age of Climate Governance

Giulia Dal Maso

Department of Asian and North African Studies, Ca' Foscari University, Venice, Italy, giulia.dalmaso@unive.it

Alessandro Maresca

Independent Researcher, alessandro.m.maresca@gmail.com

Abstract: Green finance is widely hailed as the solution to environmental and capitalist crises, promising to address climate change and secure future returns. Yet, rather than being market-driven, it increasingly relies on data-intensive forecasting models and scenarios that resemble economic planning. Drawing on case studies of sustainability-linked bonds within the International Capital Market Association (ICMA), climate stress tests by central banks, and asset managers' green portfolio strategies, we reveal how big data and algorithmic tools produced outside the market are pivotal to green finance. Although these practices expose contradictions, they also hold transformative potential. Through a financially led undemocratic form of planning, green finance wields powerful instruments we cannot leave solely to elite control. If finance is abandoning its neoliberal market addiction, then we must likewise transcend our inability to envision alternative futures. In acknowledging that planning is already happening, we can reclaim and redirect these tools towards more democratic ends.

绿色金融一直被并仍在被广泛赞誉为解决环境和资本主义危机的方案，它承诺应对气候变化并确保未来回报。然而，它并非由市场驱动，而是越来越依赖于数据密集型的预测模型和情景，这类似于经济计划。通过借鉴国际资本市场协会(ICMA)的可持续发展挂钩债券、中央银行的气候压力测试以及资产管理公司的绿色投资组合策略等案例研究，我们揭示了在市场之外产生的大数据和算法工具如何对绿色金融至关重要。尽管这些实践暴露了矛盾，但它们也蕴含着变革的潜力。通过一种由金融主导的、不民主的计划形式，绿色金融挥舞着强大的工具，我们不能将这些工具完全交由精英控制。如果金融正在放弃其新自由主义市场瘾，那么我们也必须同样超越我们无力构想替代性未来的局限。在承认计划已然发生的同时，我们可以收回并重新引导这些工具，朝向更民主的目标.

Keywords: climate change, green finance, financialisation, economic planning

Introduction

Green finance has been heralded as "the" solution to the double crises concerning the environment and capitalism. By embedding environmental policies into the financialisation of capitalism, green finance promises to tackle the problem of

climate change while guaranteeing future returns. To re-legitimise a financial elite after the global financial crisis, green finance has expanded globally, with states and private actors collaborating in the creation of financial instruments such as green bonds, green securitisation, and public–private risk-sharing instruments as well as leverage assets labelled as "green" (Maresca et al. 2023). This greenness is supposed to define their underlying capacity to invest in energy-efficient infrastructures, carbon reduction, and biodiversity projects. Importantly, for both proponents and critics of green finance, the market—and its malfunctioning—is believed to be the driver of the transition.[1]

In this article, we debunk this narrative. Contributing to the literature on green finance—and in particular on the role of finance in nature–society relations that has been advanced in critical geography and related disciplines (Bridge et al. 2020; Castree 2010; Christophers 2022; Dal Maso 2024; Dal Maso et al. 2022; Mawdsley 2018; Robertson 2012; Sullivan 2013), we aim to highlight the paradox that lies at the heart of green finance rhetoric. By exploring how climate finance co-opts computational tools to advance economic trajectories in relation to climate change, we claim that we are increasingly seeing a form of both "concealed" and undemocratic economic planning which replaces market mechanisms. Intersecting with another subliterature that points at the already existing dimension—as well as the potential—of economic planning within and beyond capitalism (Benanav 2022; Braun 2015; Durand et al. 2023; Groos 2021; Holgersen 2020; Jones 2020; Morgan 2023; Sorg 2025), we point out the inherent ontological contradictions of green finance developments but also hint at their potentials. Green finance rhetoric frames environmental problems and climate change as issues of negative externalities and market failure (Endres 2011; Harris and Roach 2017; Jäger and Schmidt 2020). The argument follows that if markets possessed complete information—such as the specific carbon emissions of each firm—they could aggregate this data to reach an optimal collective equilibrium, thereby imposing the necessary discipline on corporations. Thus, the market's current failure to address environmental problems is often attributed to informational deficiencies, particularly the inability to account for so-called "externalities".

In this paper, we argue that while green finance presents itself as relying on market neutrality to address the climate crisis, it in fact depends heavily on data infrastructures and algorithmic calculations that originate outside the market sphere. This reliance, we suggest, marks a qualitatively new configuration—an epistemological shift in financial governance (Dal Maso and Maresca 2022; Paterson 2020)—one increasingly driven by data and modelling techniques. We identify this shift as the emergence of *algorithmic planning* in green finance. Between 2015 and 2022, green finance underwent a rapid transformation. A new infrastructure of anticipatory governance emerged—one that no longer simply corrected market failures through information disclosure but instead sought to *pre-empt* market signals using data-driven tools. At the centre of this shift are institutions such as the Task Force on Climate-related Financial Disclosures (TCFD) and the Network for Greening the Financial System (NGFS). The TCFD, launched

by the Financial Stability Board, provides a widely adopted framework for firms to report climate-related financial risks to investors and regulators. The NGFS, a coalition of central banks and supervisors established in 2017, works to embed climate risk into monetary policy and financial oversight. Together, these institutions have promoted tools like Integrated Assessment Models (IAMs), climate stress tests, and forward-looking transition scenarios—not just to assess risks, but also to shape capital allocation ahead of market shifts.

This marks a significant departure from earlier, disclosure-centred approaches. Instruments such as the EU Taxonomy, scenario-alignment metrics, and mandatory transition plans have created a distributed yet hierarchical form of coordination, where credit is steered by modelled carbon budgets and sector-specific pathways. Even as political backlash has slowed progress, the underlying computational architecture continues to guide financial flows, reflecting a deeper transformation in the logic of green finance. To understand this shift, we turn to a long-standing but newly relevant debate: the socialist calculation debate. This 20th century argument pitted centralised economic planning against the self-regulating market, questioning whether computational systems could substitute for price signals in coordinating complex economies. Revisiting this debate today, we observe that green finance is progressively enlisting an infrastructure of algorithmic forecasting and planetary-scale data to determine how resources should be allocated in response to climate change (Edwards 2010, 2017; Mason 2016; Morgan 2023). As Lange (1967:161) once imagined, the computer "fulfils a function which the market never was able to perform"—not as a replacement for planning or markets, but as a new mediating instrument between them (Pasquinelli 2023).

Our argument is that despite its rhetorical commitment to market neutrality, green finance increasingly operates through a concealed form of *algorithmic planning*. This planning is not centralised in the traditional sense, but distributed across models, dashboards, standards, and climate scenarios. Aligning with scholarship that underscores the inherent role of planning in capitalist economies (Bratton 2016, 2019; Jameson 2009; Sorg 2025), we show how today's socio-ecological crisis has intensified and reconfigured this dynamic—particularly in finance. Building on Benjamin Bratton's (2019) concept of planetary geoeconomics, we argue that contemporary climate governance increasingly relies on what Science and Technology Studies scholar Paul Edwards (2017)[2] terms a planetary knowledge infrastructure—a sociotechnical system that renders the atmosphere, oceans, supply chains, and financial flows legible as components of a computable regime. While political economists Gabor and Braun (2025) offer a valuable two-axis typology of green macro-financial policies ("discipline for capital" and "expenditure"), their framework largely brackets the epistemic infrastructures that underpin these governance systems. Carbon pricing mechanisms, state subsidies, and sectoral decarbonisation pathways all depend on algorithmically generated models and metrics—from carbon accounting protocols to scenario-based climate projections. Far from a speculative ideal, this infrastructure is already operational in both market-based and state-led green finance initiatives,

mediated through satellite surveillance, computational modelling, and standardised carbon audits. Yet its apparent technical neutrality obscures deeper political asymmetries: by invoking planetary-scale governance without interrogating its embedded relations, such systems risk naturalising the transnational extractive circuits that reproduce climate vulnerability. Consequently, neglecting this infrastructural layer does not merely produce an analytical blind spot—it also allows seemingly technocratic rationalities to mask how political and financial elites displace democratic deliberation over ecological futures.

Methodology

This article draws on a 3-year multi-sited ethnography (2020–2023). We used an inductive tracing methodology (Braun 2022; Trampusch and Palier 2016) to map how planning logics emerge within green finance's so-called "black box". We conducted 32 semi-structured interviews with central bank supervisors, asset-management risk-modellers, ICMA working-group members, environmental, social and governance (ESG) data-vendors, and climate-model developers; all quotations are anonymised by role and date. Fieldwork especially included participant observation at industry workshops and working groups (ICMA working groups, 2020–2023) and hands-on sessions with trading tools such as Refinitiv Eikon and scenario explorer tools such as NGFS scenario explorer. Triangulating interview transcripts, observational notes, and documentary material (stress-test templates, bonds term-sheets, scenario code) allowed us to trace how algorithmic planning is operationalised across supervisory, banking-book, and capital-market contexts.

The article proceeds as follows. First, we unpack the dominant narrative in sustainable finance and identify its internal contradictions, especially the tension between information disclosure and market primacy. Second, drawing from the socialist calculation debate, we examine the growing primacy of algorithmic and data-based coordination over traditional market mechanisms. Through empirical case studies, we outline three distinct varieties of this concealed planning. Third, we address the political and extractive implications of these techniques, while also acknowledging their progressive potential for climate governance. Finally, we argue that unless green finance is subjected to democratic control and ecological orientation, its current trajectory risks deepening the very crises it claims to mitigate. Rather than simply expanding the green state, the challenge is to ensure that its financial tools are governed through a *planetary* lens—one that begins, rather than ends, with ecology.

From Market Corrections to Algorithmic Planning

Green finance allegedly adopts a disclose-and-punish governmentality, wherein regulators, supervisors, and standard-setters impose non-financial disclosure (NFD) requirements to compel capital users to disclose climate-related project or asset data. Proponents of this neoliberal orthodoxy argue that such disclosures enable investors to independently assess climate risks. Through the price mechanism, this

information is aggregated by the market, ostensibly facilitating efficient capital reallocation from declining to expanding sectors. This vision of "sustainable finance" was notably articulated by Mark Carney, former Governor of the Bank of England, in his influential 2015 speech, "Breaking the Tragedy of the Horizon" (Carney 2015). Echoing Carney, a senior official at a major supranational public bank remarked in our interviews that financial markets should serve not merely as fundraisers but as instruments of "clarity at the service of society". Emphasising green finance's potential, he argued that "animal spirits must be led on a leash", transforming markets into spaces of "true and accountable discourse". These statements resonate with Michel Foucault's analysis of neoliberalism's core paradox: a system of rules (e.g. NFDs) structuring an ostensibly spontaneous economic order (Foucault 2008:174).

Green finance has often been interpreted as a neoliberal governance model reliant on disclosure (Bracking 2015; Christophers 2017; Sullivan 2013). Yet our research suggests it has been evolving beyond mere information-based regulation. Alongside the proliferation of environmental labelling (e.g. avoided CO_2 metrics) and NFD standardisation, green finance appears to be driving a deeper restructuring of production systems—one mediated by data and algorithmic infrastructure. This shift moves away from a "quintessential neoliberal governance" (Christophers 2017) towards what some term technocratic Keynesianism (van 't Klooster 2022) or green Keynesianism (Mann and Wainwright 2018, 2019). Without revisiting longstanding debates about green finance's neoliberal character (Bruff 2014; Fabry and Sandbeck 2019; Panitch and Konings 2009), we observe an initial transformation: stricter NFD legislation (e.g. EU Taxonomy, China's Green Catalogue) has compelled private actors to adopt higher standards. Meanwhile, central banks now deploy climate stress tests to assess financial institutions' alignment with decarbonisation pathways (ECB 2022; FSI 2021; NGFS 2022). Voluntary frameworks like the TCFD are yielding to mandatory regimes, with supervisors assuming more assertive roles (IPCC 2022; KPMG 2023). This marks a departure from market liberalism, reintroducing elements of credit guidance (van 't Klooster 2022).

We point to an additional evolution that goes beyond regulatory adjustments and risk alignment. Green finance developments have increasingly attempted to align capital allocation not merely with regulatory compliance but with computational models—such as those developed by the IEA and NGFS—that prescribe investment trajectories across sectors and timelines. While earlier taxonomies (Jäger and Schmidt 2020) categorised projects based on regulatory eligibility, more recent frameworks (Dikau et al. 2022) analyse corporate transition plans, highlighting the emergence of *algorithmic planning*, in which multi-year decarbonisation blueprints—structured in advance by scenarios—begin to displace the market's traditional function of discovery. This shift transcends traditional state–market dynamics. While neoliberalism has long relied on state scaffolding (Mirowski 2013), green finance introduces predictive infrastructures that preconfigure economic action at planetary scales. Carbon pricing and emissions trading retain a price-signal logic, but tools like integrated assessment models and scenario-based key performance indicators represent a rupture. Financial markets

no longer "discover" pathways; they transmit algorithmically scripted futures. As we will discuss at length in the following sections, the NGFS's climate stress tests exemplify this: climate-related disclosure data feeds into scenario engines, rendering markets transmission channels rather than discovery mechanisms. The model is the signal.

Finance has always employed calculative devices to manage complexity. But green finance embeds planetary-scale planning into market operations. This shift is historically specific and technology co-determined: NFDs have evolved from basic CO_2 accounting to scenario-based assessments benchmarked against IEA/NGFS models. Early green bonds reflected minimalist reporting, but post-TCFD (2015) and NGFS (2017), disclosures now prioritise forward-looking risk modelling. Today, NFDs feed IAMs to evaluate institutional alignment with prefigured pathways (e.g. ECB [2024] climate stress tests). Once voluntary, these regimes are now mandatory in key jurisdictions, transforming environmental bookkeeping into anticipatory governance. This logic closely echoes what Davies (2015) has recently called the "socialist calculation reboot": the idea that digital infrastructures—once beyond the grasp of early socialist planners—may now offer new capacities for economic coordination that bypass market signals entirely. While Davies presents this as a moment of historical irony and speculative potential, our analysis shows that such capacities are already being deployed—not to democratise economic planning, but within financial institutions that remain largely insulated from public control. This raises fundamental questions about the political direction of such infrastructures: who codes the models, who owns the data, and whose futures are being planned?

To better illustrate our case studies, Table 1 lays out the macro-financial regimes alongside the algorithmic and planetary infrastructure layer that recurs in the SLB and stress-testing sections. Table 1 previews the regimes we analyse; we then populate the map empirically in later sections of this article and synthesise implications. Building on Daniela Gabor and Benjamin Braun's (2025) macro-financial typology, Table 1 explicitly adds an algorithmic layer—the computational engines that now steer allocation. By distinguishing the feedback infrastructures through which those algorithms operate the gap between planetary knowledge infrastructure (PKI) and purely financial-pricing loop (FFI) becomes evident. Reading down the rows shows how each regime combines these layers, revealing when finance remains sovereign and when it is really subordinated to global geo-economic modelling.

A brief discussion of the EU Net-Zero Industry Act (NZIA) will illustrate the table. While Gabor and Braun (2025) insightfully classify it as an instance of "robust derisking"—a macro-financial regime characterised by low discipline for capital and high public spending aimed at incentivising cleantech manufacturing—their analysis overlooks the algorithmic infrastructure underpinning such interventions. Central to the NZIA strategic orientation is its reliance on global and downscaled IAMs, whose scenario filtering embeds geopolitical imperatives into ostensibly scientific exercises. While we agree that the NZIA was (also) driven by geopolitical motives—especially concerns over technological sovereignty and energy security

Table 1: Sustainable-finance regimes, algorithmic layer and planetary geo-economics (building on Gabor and Braun 2025)

Regimes	Core mechanism	Algorithmic planning layer	Planetary geoeconomics stance
Neoliberal disclose-and-punish	Publish climate metrics; prices move capital	Marginal. Market-price discovery; almost no scenario engine	Pure FFI—price-centred; PKI marginal
Weak de-risking state	Public guarantees shave risk, valuation left to markets	Emerging. IAM pathways often only footnoted	FFI with thin PKI plug-in
Robust de-risking state	Large subsidies/credit lines crowd in finance, minimal discipline	Emerging. Guarantee portals screen for IEA/NGFS alignment	Hybrid (loose): PKI, nationally declined, gates entry, FFI prices assets
Big Green State	State missions fund techno-economic road-maps	Well-entrenched. Cost-curve models linked to global IAM DBs; KPI dashboards	Hybrid (loose→tight): nationally declined PKI informs missions; FFI transmits
Green credit guidance	Stress-tests bake NGFS scenarios into capital rules	Pivotal. Stress-test engines and portfolio tools coupled to IAM outputs	Hybrid (tight): PKI sets binding FFI constraints. Planetary
Democratic eco-planning	Citizens' assemblies set carbon budgets, steer lending	Pivotal. Open-source, collectively determined IAMs forks.	PKI first, FFI second—planetary models under civic control
Degrowth / post-growth	Sufficiency metrics contract high-carbon credit	Bio-physical throughput models; material-flow engines	Alt-PKI—eco-physical accounting; minimal FFI

FFI = financial feedback infrastructure; PKI = planetary knowledge infrastructures. Rows show how algorithmic computation evolves—from price algorithms (Row 1) to scenario engines (Row 5) and ultimately to civic or eco-physical modelling (Rows 6 and 7). True planetary geoeconomics emerges only when PKI subordinates, rather than merely informs (or is subsumed in) the financial loop. We refer back to specific rows in each empirical section.

—this is most clearly legible in the structure and logic of the modelling algorithms themselves, not in its macro-financial architecture. The post-Ukraine recalibration of energy security priorities—coupled with concerns over EU technological dependence on China and the United States—has led to the selective inclusion of IAMs that reflect reduced Russian gas supply, accelerated reshoring of green manufacturing, and critical raw material constraints.

More specifically, the International Institute for Applied Systems Analysis (IIASA) and the Potsdam Institute for Climate Impact Research (PIK)[3] were explicitly asked by the European Scientific Advisory Board on Climate Change to update their scenario ensemble to reflect these new geopolitical realities, incorporating 30 additional pathways that could account for post-2022 conditions (IIASA and PIK 2023:11).[4] These algorithmically filtered scenarios are presented as technocratic feasibility assessments, but in fact encode political choices about acceptable industrial futures. As such, the NZIA does not merely subsidise capital expenditure with little discipline in green sectors; it operationalises a form of algorithmic governance wherein geopolitical anxieties are translated into model parameters, narrowing the perceived space of economically and ecologically "viable" policy options.

Sustainable Finance Plans: Hayek Meets Walras

Integrated assessment models (IAMs) are computational tools that simulate future scenarios to evaluate the long-term consequences of present decisions (Anderssson 2018; Rindzeviciute 2016), building on foundational work like *The Limits to Growth* (Meadows et al. 1972). Developed by an international scientific network coordinated by the IPCC, these models synthesise climate and economic data (Cointe 2023; Edwards 2010). Despite their technical complexity (Riahi et al. 2017), their core function is clear: they integrate greenhouse gas emissions into economic simulations, quantifying sector- and region-specific climate impacts (Bosetti 2021; Metcalf and Stock 2017).

The IEA and NGFS employ disaggregated process models, which differ from abstract benefit–cost approaches by providing granular projections of climate policy effects (IPCC 2022; Weyant 2017). By simulating variables like technological development and lifestyle shifts (Riahi et al. 2017), IAMs translate hypothetical futures into actionable metrics. For instance, the *Net Zero Scenario* outlines a 2050 carbon-neutral economy, detailing sectoral transitions in energy, transport, and agriculture (IEA 2021). These models thus exercise a performative, world-making power, generating politically potent visions of the future (Beck and Mahony 2018) —effectively functioning as algorithmic planning tools.[5]

From Socialist Calculation to Financial Planning

The computational logic underpinning IAMs traces back to early 20th century debates on economic planning. Enrico Barone (1908) and Oskar Lange (1936, 1937) proposed solving Walrasian[6] equilibrium equations algorithmically—a task Lange (1967) later argued could be automated via cybernetics.[7] Where markets

rely on *tâtonnement* (trial-and-error price adjustments), Lange envisioned computers simulating this process to optimise planning within constraints, bridging "market spontaneity" and "centralised" control (Pasquinelli 2023). Paradoxically, these once-socialist tools now underpin sustainable finance. While Hayek (1945) dismissed centralised data aggregation as incompatible with tacit knowledge (see Saros 2014), modern models circumvent this critique by standardising information through machine-readable disclosures. NGFS and IEA scenarios no longer merely *inform* markets but *prescribe* capital allocation.

Far from signalling a return to state-led Keynesianism, the emerging mode of planning in green finance is decentralised yet hierarchical. Whereas 20th century socialist calculation debates imagined central planners endowed with perfect information (Mises 1920), today's computational tools distribute planning across networks without democratising it—a paradox we revisit in the conclusion. Davies (2015) argues that contemporary algorithmic infrastructures may finally enable the kind of economic coordination envisioned by early socialist planners, yet in practice, these tools are deployed in service of technocratic control rather than democratic deliberation. In this light, the shift cannot be dismissed as merely an instance of neoliberalism's "adaptive resilience" (Mirowski 2013). Earlier interventions sought to naturalise market imperatives (Peck and Theodore 2012); algorithmic planning, by contrast, embeds them within often opaque, model-driven infrastructures. The task, then, is no longer to ask whether markets are free, but rather: who designs and governs the algorithms? The following sections trace this question through the architecture of the green finance apparatus.

Feedback Infrastructures and the Eclipse of Competition

Hayek's (1945) insistence on markets as irreplaceable information processors falters in light of contemporary data infrastructures. Sustainable finance replaces dispersed knowledge with standardised metrics—encoded in labels, ratings, and mandatory disclosures (Dodge and Kitchin 2005; Jameson 2009). This "accounting mega-machine" feeds climate-related data into IAMs, functioning as an Anthropocene knowledge infrastructure (Edwards 2017): a socio-technical system that routes and processes data across temporal and spatial scales (see also Bratton 2016, 2019; Mitchell 2020; Morozov 2019). Critically, this infrastructure does not *emerge* from market competition but *supersedes* it. By simulating virtual "planners" (Bosetti 2021:6), IAMs reduce markets to passive actuators within a preconfigured system—a stark departure from Hayek's "design for competition" (Morozov 2019; Roth 2015).

Concealed Planning

International Capital Market Association and Sustainability-Linked Bonds

The International Capital Market Association (ICMA) occupies a unique space in global financial governance. As a self-regulatory organisation, it brings together

banks, institutional investors, corporations, and professional service firms to collectively define the norms and standards of international capital markets. Its influence extends across both primary and secondary markets, offering rules, recommendations, and training that help coordinate market practices outside formal legal frameworks. While not a public authority, ICMA's guidelines often operate with quasi-regulatory weight, shaping how new financial instruments are designed, disclosed, and adopted across jurisdictions. ICMA periodically calls its members for joint work on specific topics to establish and agree on conventions and standards. Since the beginning of 2020, one of the authors of this paper has participated in meetings and working groups organised by ICMA to standardise a new sustainable financial instrument, the sustainability-linked bond (SLB). Chaired by a leading US investment bank, the group has been attended by bankers, investors, corporations, and accountants, producing several recommendations, standards, and guidelines.

The recent ICMA standards issued for a new financial instrument (sustainability-linked bonds, or SLBs) offer a vantage point to explore the inner workings of the "feedback infrastructure" emerging around climate scenarios and the pivotal role key performance indicators (KPIs) play in it. In simple terms, a sustainability-linked bond (SLB) is a plain bond with a built-in climate bet: if a company misses specific, pre-agreed climate targets, its interest rate steps up. Those targets—and how they are measured—are set in the bond documentation and tracked through a handful of key performance indicators (e.g. emissions intensity). The mechanics discussed below just formalise this idea. We outline how KPIs are built (metric, baseline, trajectory, test date) and why this design embeds scenario models directly into the bond's conditions. The structure of a sustainability-linked bond is simple. Unlike green bonds, social and sustainability bonds, which are "use-of-proceeds" instruments, SLBs are for general purposes. This means that their proceeds do not need to be earmarked for specific green projects, as happens for green bonds. Instead, an SLB issuer commits to achieving well-defined sustainable targets (sustainability performance targets, SBTs) within defined timeframes. The progress towards these targets is assessed through predefined Key Performance Indicators. If the target is not fulfilled, the issuer must pay more interest (ICMA 2024). As one of the first SLB issuers stated, the strategy consists of "linking the Sustainability strategy of the issuer (or borrower) to the terms of general corporate purposes debt, incentivizing the achievement of pre-determined Sustainability performance targets" (ENEL 2020) (see Figure 1). Thus, an SLB encodes the commitment of its issuer to a transition plan, a detailed temporal map of targets and actions, as we defined in the previous sections.

Addressing Key Performance Indicators

Sustainability-linked bonds represent a pivotal shift in how information and data are assessed. In the early 2010s, the sustainable bond market relied on simplistic accounting, often limited to basic CO_2 emissions reporting. Today, impact reports for such bonds are far more complex, referencing explicit quantitative scenarios

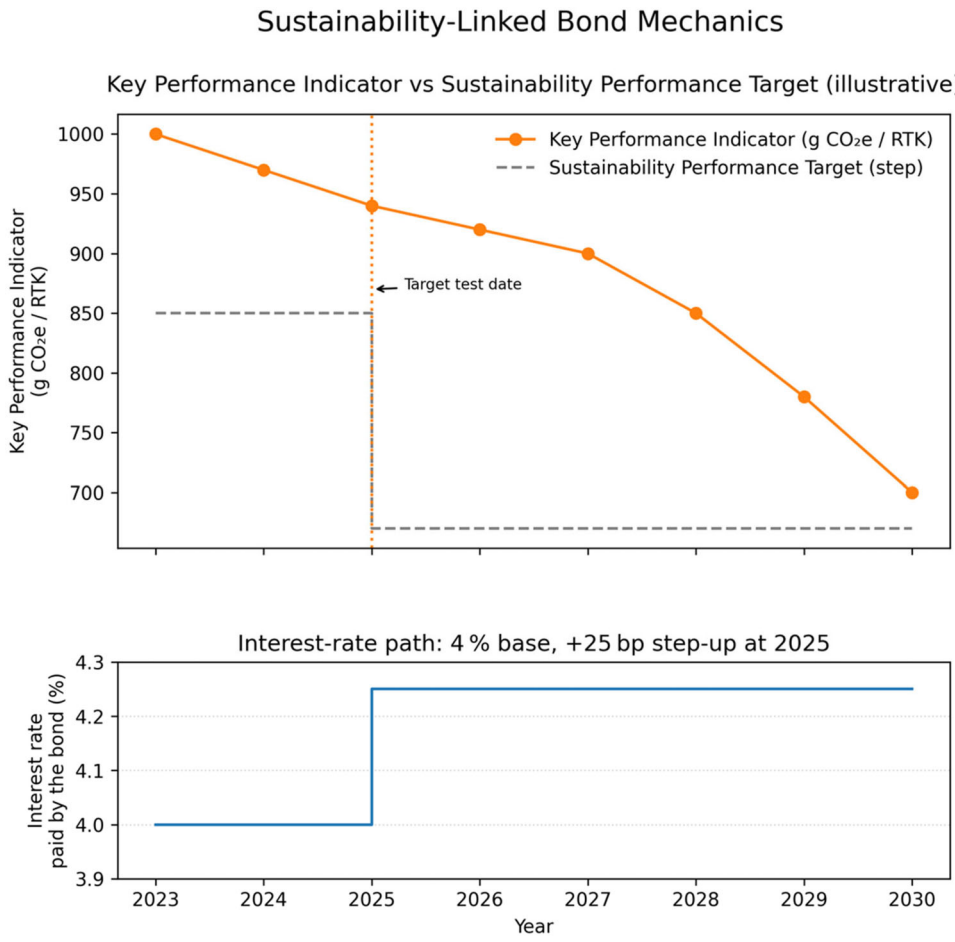

Figure 1: Fictional sustainability-linked bond (SLB) for an airline (source: authors). This schematic illustrates how a general-purpose SLB hard-codes a decarbonisation pathway into the bond's financial terms. The issuer—here a notional airline—pledges to cut its operational greenhouse-gas intensity (g CO_2e per revenue-tonne-kilometre) in line with the International Energy Agency's Net-Zero 2050 roadmap, as independently validated by the Science-Based Targets initiative (SBTi). If the intermediate Sustainability Performance Target (SPT) is missed on the test date, the coupon automatically steps up by 25 basis points, creating a "real-time" feedback loop that channels algorithmic planning through capital markets. Rather than waiting for dispersed price signals to emerge, the structure embeds a modelled future in advance, exemplifying the article's argument that green finance increasingly replaces market discovery with data-driven economic coordination

from institutions like the IEA, implemented through Key Performance Indicators (KPIs). These are the hinge between scenarios and cash flows. They name the variable (e.g. airline CO_2 intensity), specify the metric (g CO_2e/RTK), and fix the trajectory (e.g. SBTi aviation curve aligned to the IEA Net-Zero scenario). Because

the metric, baseline, and target date are defined ex-ante, the bond's coupon adjusts mechanically if performance deviates—turning an integrated assessment model into a micro-governance device for corporate finance. By linking non-financial disclosures to climate scenarios, KPIs make economic activities "addressable" within computational systems (see Bratton 2016; Dhaliwal 2022).

Scholars have explored how KPIs operationalise the "connection between sustainability and financial markets" (Hiss 2013:240). Acting as infrastructural gateways (see de Seta 2023), KPIs blend environmental and financial assessments, mapping economic activities into climate scenarios. This supports the allocation of capital to meet sustainability requirements while aligning financial instruments with climate goals. Their design embodies the intersection of accounting and financialisation (Callon and Muniesa 2005; Hiss 2013; Power 2004). By linking bonds to IEA and NGFS scenarios[8] (see Figures 2 and 3), KPIs shape how financial

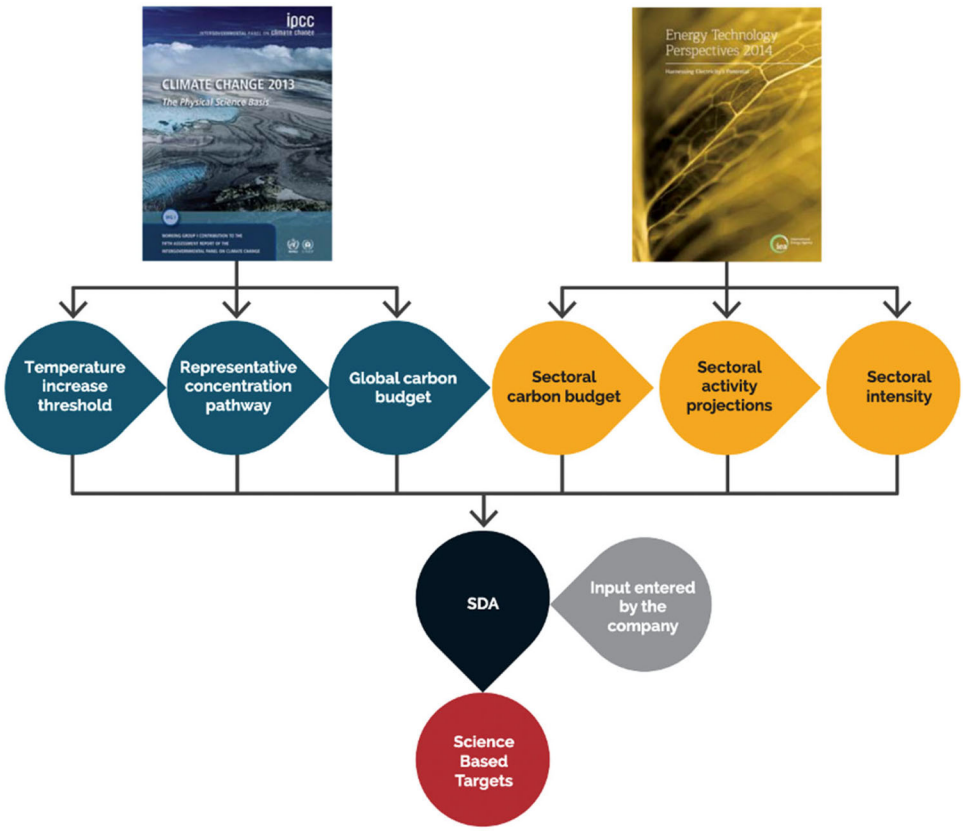

Figure 2: Development of the method used by SBTi (source: SBTi 2015:20; CC BY 4.0). The Science-Based Targets initiative's Sectoral Decarbonisation Approach (SDA) takes IPCC climate limits and IEA sector outlooks—both generated with integrated assessment models (IAMs)—to translate a global carbon budget into sector-specific pathways (e.g. power, steel). Firms then plug in their own activity data (production, sales, etc.) to derive a company-level emissions trajectory aligned with those modelled pathways

Figure 21. Scope 1 carbon intensity

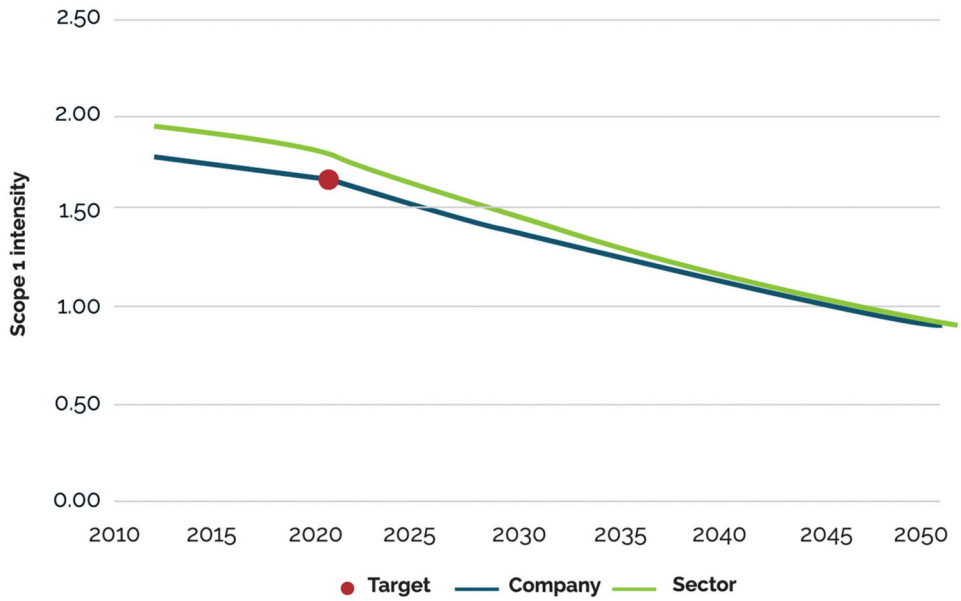

Figure 3: Science-Based Target decarbonisation curve (source: SBTi 2015:42; CC BY 4.0). This chart translates the IEA's sectoral energy-system model into an emissions-intensity glide-path that individual companies must follow to claim Paris-aligned targets. The green line plots the required sectoral annual decline in carbon intensity from the 2010s to mid-century, while the blue line represents company-level trajectories under the SBTi Sectoral Decarbonisation Approach. Because the curve is derived from an Integrated Assessment Model, it embeds assumptions about technology deployment, demand management, and carbon-budget constraints—turning abstract climate modelling into an operational benchmark for corporate finance. When issuers adopt this curve as the reference for SLB KPIs, they transform a global planning apparatus into a binding micro-level governance tool

instruments adhere to dominant climate pathways, facilitating a feedback loop that connects financial flows with sustainability objectives (see Fourcade and Gordon 2020; Scott 1998).

Central to this evolution is the concept of "double materiality". Traditionally, financial materiality refers to factors significantly affecting an issuer's economic performance. Double materiality adds a second dimension, considering the issuer's impact on broader environmental and social issues. However, this concept remains debated. Should KPIs measure how environmental factors affect an issuer's operations, or vice versa? ICMA suggests blending these dimensions through a "basket" of KPIs capable of addressing both perspectives. To resolve ambiguity, a working group[9] developed an "Illustrative KPIs" list tied to IEA and NGFS scenarios, offering standardised metrics for issuers and reviewers (ICMA 2025; IEA 2021; NGFS 2022).

Practitioners have embraced this alignment for two reasons. First, hegemonic scenarios serve as public-facing "brand logos" (Lury 2004), consolidating expectations and narratives (Chong and Tuckett 2015). Second, only these scenarios make KPIs genuinely double material by addressing both financial and sustainability dimensions. As such, KPIs enable sustainable bonds to play a hybrid role: they act as financial instruments while simultaneously embedding economic activities within climate monitoring systems (Bratton 2019). However, this connection is not straightforward. Translating scenario variables into indicators requires financial organisations to act as intermediaries, introducing complexity and potential frictions.[10] These layers create opportunities for financial actors to exploit ambiguities, adding a dimension of strategic play within the system.[11]

This emerging architecture of scenario-aligned KPIs echoes an earlier vision of economic accounting, one articulated by Karl Polanyi in his 1922 critique of Mises. In contrast to Mises' defence of pure price calculation, Polanyi called for a more comprehensive form of accounting—one capable of capturing the full social (and today we might add environmental) costs of economic activity. What he imagined was a mode of rational economic planning grounded in visibility: if all costs (social and environmental) could be rendered legible, then collective decision-making could follow. In principle, today's climate-aligned KPIs promise just that: to make planetary limits calculable, thus enabling better decisions. But in practice, the KPI regime remains subordinated to the logic of capital accumulation. Rather than expanding the scope of economic rationality, KPIs often reduce sustainability to a series of discrete, audit-ready metrics that can be priced, traded, and optimised within financial portfolios. Even when aligned with 1.5°C scenarios, they serve primarily to secure investability. As Rief (2022) argues, such representational regimes do not offer a holistic overview of socio-economic processes but reformat them to fit the epistemic and operational needs of finance. Moreover, the growing reliance on KPIs introduces new strategic spaces for ambiguity and manipulation. Financial actors can selectively disclose or interpret metrics, delay penalties, or structure targets in ways that preserve flexibility rather than enforce accountability. Green finance, in this sense, becomes a space of tactical adjustment, not just environmental responsibility. It offers a partial, fragmented picture —a perversion from Polanyi's hope for economic transparency rooted in social purpose. It falls short of a "full overview" of social utility and redistribution. Contrary to what Polanyi had hoped for, they seem increasingly dissociated "from people's first-order accounts of their values, motives and experiences" (Rief 2022:12).

Climate Stress Tests

While not the result of "market-led" initiatives as in the case of ICMA bonds, climate stress tests mandated on financial institutions by public supervisors also rely on hegemonic climate scenarios. Their primary goal is to assess future exposures and potential losses that cannot be extrapolated from past data, such as those related to climate risk (Bolton et al. 2020:3). Thus, aiming for "changes in

incentives of the supervised financial actors, both public and private" (IPCC 2022:1580), they ultimately attempt to tilt capital allocation towards low-carbon investments (van 't Klooster 2022), as in the case of ICMA bonds.

Indeed, the recognition that climate will ultimately have an impact on financial risk (Carney 2015; NGFS 2022) has worked as a catalyst for the development of the NGFS. In the form of a network comprising 114 central banks (and counting), financial supervisors, and observers, the NGFS was born with the aim of developing new policies and interventions needed by the financial system to counter climate change and to undertake a low-carbon transition. As we have previously highlighted, the response to climate-related risk has been to mobilise what have been considered "market correcting strategies", which entails feeding the market with the information it needs to adjust itself in the right direction to tackle climate change. This trend has seen the materialisation of the Task Force on Climate-related Financial Disclosures (TCFD) that the Stability Board and the NGFS has supported to develop, and which has increasingly translated into a new form of disciplining that has seen business and financial actors having to disclose climate-related financial information.

Additionally, however, the main activity of the NGFS has been to (1) promote climate stress tests that provide better assessments of the resilience of specific banks and financial systems and (2) outline supervisory objectives to face the challenges posed by climate change. Defined as part of a forward-facing vision, these tests employ climate scenarios to guide prudential authorities and central banks towards a low-carbon economy transition. They provide planetary scientific expertise upon which financial institutions can rely in order to better tailor their interventions. Depending on the targets, scenarios are mostly generated by IAMs on the basis of the notion of physical and transitional risks. They are thus classified as orderly (lower physical, lower transitional risks), disorderly (lower physical, high transitional risks), and hot-house world (higher physical and low transitional risks) to target end-of-century temperatures warming of between 1.5°C and 3°C, respectively (Battiston et al. 2021). These are informed by—and produced with—the latest estimates from the International Monetary Fund (IMF) and are able to provide detailed sector-by-sector analyses, informing targets and strategies focused on industrial and transportation or energy guidance. Scenarios can foresee which technologies, and how much of these technologies, are required to reduce emissions and offer economic models in order to guide companies and economic market actors to reduce carbon emissions (Carlin 2022).

Importantly, scenarios can analyse potential losses of banks financing carbon-intensive businesses. They play a fundamental role in the wider mechanisms of supervisory contexts, as they can assess the extent to which climate-related risk can ultimately impact bank capital requirements (van 't Klooster and Prodani 2025). As noted by van 't Klooster (2022:782), this denotes a radical paradigm shift, one which sees a supervisory authority engaged in not only changing the tools they have at their disposal for regulatory purposes but also a deeper epistemological reckoning regarding their "understanding of what problems they should solve". While indeed "central banks are constrained in greening financial

flows by their continued adherence to monetary dominance" (Kedward et al. 2024:1593)—the ultimate reference to scenarios as a guide to credit allocation brings new technological visions, a final scope and pattern to follow, which makes a coordinating role for the market seem increasingly distant.

Conclusion

We traced how the green finance apparatus has become increasingly reliant on big data and algorithmic modelling, embedding climate change—understood as climate risk—within the frameworks of financial optimisation. In doing so, green finance does not so much disrupt capital's logic as extend it, treating climate risk as a new horizon of asset valuation (Fraser 2021). Climate science, once mobilised for public interest, is now being selectively absorbed into financial tools that, under the banner of "sustainability", reinforce deeply technocratic and exclusionary forms of governance. By analysing tools such as sustainability-linked bonds and climate stress testing, we showed how climate scenarios and data governance, when co-opted by financial and regulatory elites, serve to consolidate institutional power rather than redistribute it.

Neoliberal approaches to environmental governance often treated data as a fixed input used to make markets more efficient—like in climate risk reporting frameworks that help investors adjust portfolios. More recent tools, such as sustainability-linked bonds and climate stress tests, go further: they automatically change financial conditions (like interest rates) based on how well a company aligns with climate goals. This creates a closed feedback loop, where algorithms replace market signals, reflecting earlier visions of the computer as a central coordinator of decision-making. But this shift is not necessarily empowering or democratic. As the typology of green financial regimes (Table 1) shows, even as these algorithmic tools start to guide investment decisions, they still operate within the logic of financial capitalism. For example, even in state-led approaches like the "Big Green State", public investments in renewable energy are evaluated against growth-focused climate models produced by institutions like the International Energy Agency.[12] Central banks that steer green lending do so by following expert-designed climate scenarios that often lack public input. While these models go beyond neoliberal minimalism, they risk replacing markets not with democratic planning, but with opaque systems where data and algorithms silently shape our ecological future.

Even a generous reading of this evolution—one that temporarily brackets concerns about systemic greenwashing—must confront the limited imaginative scope of these interventions. Financial institutions predominantly rely on scenario narratives the IPCC (2022) terms "middle of the road", which assume that society will continue to evolve in line with historical trends (NGFS 2022). These models project continuity, not transformation. Echoing Donna Haraway's (2018:135) warning against the fetishisation of models, we argue that these scenarios must be understood as situated and political—not neutral tools, but "engaged, inhabited, lived".[13] As we have shown, particularly through the case of sustainability-linked

bonds, the growing entanglement of finance and climate modelling creates a feedback loop that amplifies their mutual performativity (Beck and Mahony 2017, 2018; Callon 2007; Cointe 2023; McKenzie 2008). Subordinated to the logic of capital valorisation, these tools are unlikely to disrupt the deep structures of social reproduction or address rising inequalities. On the contrary, they may serve to further entrench them.

This reveals a deeper problem, one that Mark Fisher (2009) termed capitalist realism: the pervasive belief that capitalism is not just the only viable political and economic system, but the only imaginable one. Green finance exemplifies this condition. It does not imagine alternatives to capitalism—it simulates their appearance through climate modelling, while reproducing the very structures it claims to reform. It is easier, in this configuration, to model the end of the world than to plan for the end of capitalism (see Jameson 2016:3). Yet if these financial planning experiments fail to deliver structural change, they nevertheless bring something else into view: they reveal that *planning is not only possible; its infrastructure is already being built*. And this insight opens a space of political possibility. As Kim Stanley Robinson (2020) writes in *The Ministry for the Future*, "Utopia is no longer a mere fantasy; it's now a critical necessity for survival" and "the most believable best-case scenario". Out of this necessity, we argue that planning must be reclaimed—not as a technical exercise, but as a political project. Democratic, redistributive, and ecological forms of planning are essential to mobilising global responses to the climate crisis and reversing the inequalities exacerbated by market-led transitions. Indeed, these very tools can be repurposed for democratic ends—provided models, data, and thresholds are opened to public contestation rather than sealed within technocratic circuits. If financiers are already relinquishing neoliberal dogma in favour of planning for capital preservation, then the left, too, must abandon its hesitation and reclaim the power to imagine—and build—alternative futures.

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Endnotes

[1] By *transition* we mean the managed reallocation of capital, infrastructure, and labour away from carbon-intensive systems towards low-carbon substitutes over the next three decades.

[2] In an early intervention, Edwards (2017:39) highlights how emerging carbon accounting systems—from GHG pricing mechanisms to climate risk valuation tools—exemplify the rise of planetary knowledge infrastructures capable of integrating ecological and economic

systems at scale. Like Jameson's (2009) utopic discussion of Walmart—whose dystopian corporate power nonetheless manifests a latent capacity for post-capitalist logistics—these infrastructures embody a dialectical tension. They render emissions, supply chains, and climate feedback loops legible in ways that could enable democratic stewardship, yet are increasingly harnessed by finance as tools of financialisation (e.g. converting carbon budgets into arbitrage opportunities). This intrinsic tension—between planetary management and financial co-optation—must be resolved not technically, but politically.

[3] Both world-leading organisations in the development of IAMs.

[4] It is worth quoting at length: "Given recent developments—including the Covid pandemic and the 2022 energy crisis caused by the Russian invasion of Ukraine—and policy processes, it becomes increasingly unlikely that … deep emission reductions can be achieved … until 2030 … 30 additional scenarios from recent research using the REMIND-EU model were included … constrained … by recent developments as well as inertia in policy processes and technology development … The scenarios were especially refined to better represent … the recent evolution of performance and market outlooks for key zero-emissions technologies like solar power, wind power, electric vehicles or CCS" (IIASA and PIK 2023:11–12).

[5] Because of their diverse and interdisciplinary nature, IAMs face critiques from multiple perspectives, primarily regarding their impracticality, complexity, abstractness, and the omission of institutional and political factors. A detailed review of these critiques is beyond the scope of this article. For a comprehensive overview, readers are directed to "Scenarios and Modelling Methods" in IPCC (2022:Annex III).

[6] Leon Walras was instrumental in introducing "the static point of view" in economics (Schumpeter 2006), establishing a framework of simultaneous equations that describe the equilibrium of various economic variables, such as prices and quantities, at a specific moment in time. Many modern integrated assessment models have evolved from this foundation, incorporating functions that perform cost-effective intertemporal optimization between equilibria at different points in time, taking into account the impacts of climate change, technological advancements, and other factors (e.g. Baumstark et al. 2021; see also, for a prescient overview, Lange 1967:160–161).

[7] Unlike Lange, Barone was not a socialist but advocated for a competent state bureaucracy dedicated to public welfare (Bradley and Mosca 2014; Schumpeter 2006:952–956). He supported Mussolini's first governments, passing away soon before dictatorship (Bradley and Mosca 2014). Clara Mattei (2022:372) notes that Barone, alongside economists like Pareto and Pantaleoni, developed his theories amidst workers' revolutionary pressures, standing fast in the "objective to protect the bourgeois order".

[8] The Air France-KLM €1 billion SLB issued in 2023 shows how leading carriers translate sector-level climate scenarios into investable terms. The bond links its coupon to a 30% reduction in well-to-wake CO_2 intensity by 2030 relative to a 2019 base, a trajectory calibrated to the aviation pathway in the IEA net-zero scenario and certified by SBTi. By tying corporate cash flows to model-derived climate physics, the instrument functions as a privately executed plan: it front loads a decarbonisation schedule, disciplines management via automatic coupon adjustments, and offers investors a measurable yardstick for climate alignment—precisely the "concealed planning" dynamic analysed (AirFrance-KLM 2023).

[9] One of the authors participated to the sessions as an observer.

[10] The Science Based Targets initiative (SBTi) figures prominently in the ICMA list. This organisation translates IAM scenarios (especially IEA) into actionable targets for corporations (SBTi 2021) and has been proposed by the US administration as a reference for federal suppliers (White House 2022).

[11] Using Bratton's language derived from computer science, they serve as "routers" for these addresses.

[12] With the risk of sliding into "green mercantilism", with powerful national states externalising land, minerals, and carbon-intensive stages of the transition to the Global South—reproducing colonial extraction under a low-carbon banner.

[13] Haraway's (2018) call to "stay with the trouble" and her outstanding work on models is sometimes folded into the popular rhetoric of an "Escape from Model Land" (Thompson 2022)—the covert suggestion that the best remedy for technocratic excess is to step outside quantitative abstraction altogether. That reading misplaces Haraway's point. She does not urge flight from models; she urges us to *live inside them differently*: to open their code, contest their assumptions, and re-make them as shared tools rather than opaque verdicts. In other words, the task is democratisation, not desertion. There is no exit from Model Land—only the possibility of governing it collectively.

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