

# Institutional Reform: Fixing the Epistemic Incentive Structure of Post-Classical Computing

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2026-07-08

**Abstract.** The first four papers in this series established that quantum computing's failure is epistemic (Phase I), surveyed alternatives (Phase II), examined physical limits (Phase III), and proposed an investment portfolio (Phase IV). This paper addresses the institutional question: why did \$35 billion of investment over two decades produce zero commercially viable quantum computers, and how do we prevent this from happening again? We diagnose the institutional incentive structure that rewards narrative production over falsifiable results --- the misalignment between venture capital fund horizons and quantum computing development timelines, the capture of government research agencies by private interests, the absence of independent verification protocols with enforcement mechanisms, and the regulatory vacuum in which quantum computing claims are made without consequence. We propose five institutional reforms: (1) an Advanced Computing Projects Agency modeled on DARPA's successful structure but restricted to post-classical computing; (2) mandatory independent verification for any quantum computing claim above a materiality threshold; (3) structural separation of quantum hardware R&D from quantum software and services; (4) reform of government procurement to require joules-per-solution metrics; and (5) creation of a public registry of claims with time-bound falsification criteria. We argue that without institutional reform, any technological advances in post-classical computing will be captured and distorted by the same incentive structures that produced the quantum computing bubble.

**Keywords.** - institutional reform, - quantum computing, - venture capital, - research policy, - DARPA, - independent verification, - science policy, - technology bubbles

## 1. Introduction: The Question No One Asks

Four papers have established a foundation. The qubit is a scaffold, not an invariant. Alternative paradigms exist with greater ontological fidelity. Physical limits impose honest boundaries. A diversified investment portfolio is both available and defensible.

But none of these papers answer the question that anyone who has watched the quantum computing industry over the past decade eventually confronts: **\*\*how was this allowed to happen?\*\***

How did \$35 billion of global investment --- public and private, spanning two dozen countries and hundreds of institutions --- produce zero commercially viable quantum computers? How did D-Wave sell "quantum computers" to Lockheed Martin and Google before independent benchmarking demonstrated no speedup? How did Rigetti reach a \$1.5 billion valuation via SPAC before its stock declined over 90%? How did Microsoft claim evidence for Majorana zero modes that was subsequently retracted, and suffer essentially no institutional consequences?

The standard answers attribute these failures to the inherent difficulty of the technology: quantum systems are fragile, decoherence is relentless, error correction is expensive. This is true, but it is also *insufficient*. Many technologies are difficult without producing systematic misinformation at industrial scale. The difficulty of fusion energy has not produced a comparable pattern of corporate claims repeatedly exceeding what independent verification can support.

The difference is institutional. The quantum computing industry operates within an incentive structure that systematically rewards the appearance of progress over actual progress --- and that is what this paper analyzes and proposes to reform.

## 1.1 The Institutional Question Restated

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The question is not "why hasn't quantum computing succeeded?" The question is: "given the institutional structure of quantum computing R&D, what outcome would a rational observer have expected?"

Our answer: exactly the outcome we got. The institutional structure --- the mix of venture capital, government grants, corporate R&D, and academic prestige economy --- is configured to produce narrative assets, not computational ones. The \$35 billion was not "wasted" in the sense of being embezzled or incompetently spent. It was efficiently allocated --- toward the production of press releases, patent portfolios, academic publications, and startup valuations that served the interests of the institutional actors involved. That these narrative assets did not translate into computational assets is not a bug in the system. It is a feature of the system's \*selection environment\*: the incentives select for narrative production, and narrative production is what we observe.

## 1.2 Structure of This Paper

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Section 2 diagnoses the institutional incentive structure in detail. Section 3 examines the structural mismatch between venture capital and deep technology. Section 4 analyzes the role of government research agencies. Section 5 proposes five institutional reforms. Section 6 addresses objections and implementation challenges. Section 7 concludes.

# 2. The Anatomy of Institutional Failure

## 2.1 The Incentive Trilemma

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Every institution funding quantum computing faces a trilemma:

1. **Honest evaluation.** The institution must be able to distinguish genuine progress from narrative production.

1. **Timely decisions.** The institution must allocate capital within timeframes consistent with its mandate (venture fund life, grant cycle, fiscal year).

1. **Competitive positioning.** In a multi-institution funding landscape, the institution must not be systematically disadvantaged relative to competitors who make more optimistic (and less honest) evaluations.

The trilemma arises because these three goals are in tension --- and, in the current institutional landscape, they are in *direct conflict*. An institution that attempts honest evaluation will be slower to fund than competitors who accept narrative claims at face value. An institution that attempts timely decisions will lack the technical depth to distinguish progress from hype. An institution that prioritizes competitive positioning will --- rationally, from its own perspective --- degrade its evaluation standards to match or exceed competitors'.

The result is a **race to the bottom in evaluation rigor**. Each institution has an individual incentive to lower its standards, and the equilibrium is a funding environment where no institution performs rigorous independent evaluation. The \$35 billion outcome is the equilibrium of this game.

## 2.2 The Narrative Production Function

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Narrative production in quantum computing follows a predictable pattern:

1. **Milestone claim.** A research group or company announces a milestone --- "quantum supremacy," "quantum advantage," "error correction below threshold" --- accompanied by a preprint, a press release, and often a prestigious journal publication.

1. **Media amplification.** Science journalists, who lack the technical expertise to evaluate the claim independently, report the announcement as fact. Headlines amplify the claim: "Google Achieves Quantum Supremacy."

1. **Capital inflow.** Investors --- venture capitalists, corporate R&D budgets, government grant agencies --- allocate capital based on the amplified claim. The capital inflow validates the claim retroactively: "if sophisticated investors are funding this, it must be real."

1. **Milestone qualification.** Independent researchers --- typically academic groups without access to the proprietary hardware --- publish analyses that qualify, contextualize, or refute the original claim: "the classical simulation was not optimized," "the problem has no commercial relevance," "the result does not generalize."

1. **Institutional irrelevance of qualification.** The qualification arrives too late to affect the capital allocation. The money has been deployed. The press releases have been written. The academic papers have been published. The qualification circulates within the academic community but does not reach investors, journalists, or policymakers. The narrative has moved on to the next milestone.

1. **Milestone creep.** The next milestone is announced, further in the future and more ambitious than the last, restarting the cycle.

This cycle --- which we term the **Narrative Production Function (NPF)** --- operates on a timescale of months (announcement to capital inflow) while independent verification operates on a timescale of years. The NPF is structurally faster than verification, which means capital allocation is always ahead of truth. This is not a failure of individual actors. It is a structural feature of the information environment.

## 2.3 The Prestige Cascade

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The NPF is reinforced by a prestige cascade within the academic community. Publication in *Nature* or *Science* confers institutional prestige on the authors, their departments, and their universities. This prestige translates into funding, hiring, and promotion --- incentives that operate independently of the long-term replicability of the published result.

A quantum computing claim that appears in *Nature* and is subsequently qualified or refuted does not typically result in retraction. The authors retain the publication, the citation count, and the institutional prestige. The qualification appears in a lower-tier journal, reaches a smaller audience, and does not affect the authors' careers.

The prestige cascade creates a **publication lottery**: the expected value of publishing an ambitious claim --- even one that may not survive independent scrutiny --- exceeds the expected value of publishing a careful, qualified result. The rational academic, optimizing for career advancement, will produce ambitious claims. The institutions that employ them will celebrate those claims. The journals that publish them will benefit from the attention they generate. The qualification and correction will be someone else's problem.

## 2.4 The Regulatory Vacuum

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Quantum computing claims are made in an essentially unregulated environment. There is no equivalent of the FDA --- an agency with the authority to require evidence of efficacy and safety before a product can be marketed. There is no equivalent of the SEC --- an agency with the authority to penalize materially misleading statements to investors. There is no equivalent of the NTSB --- an agency that investigates failures and publishes findings that affect future practice.

The regulatory vacuum is not an accident. It reflects a deliberate policy choice: "innovation" is prioritized over "consumer protection." The assumption is that the market will sort out which claims are valid and which are not --- that investors will perform due diligence, that journalists will exercise skepticism, that the academic community will self-correct.

The evidence from two decades of quantum computing suggests that none of these mechanisms are sufficient. The market does not sort; it amplifies. Investors do not perform due diligence; they perform pattern-matching on narrative features ("PhD founders," "Nature paper," "DARPA grant"). Journalists do not exercise skepticism; they amplify press releases. The academic community does self-correct --- but on a timescale that is structurally irrelevant to capital allocation.

## 3. Venture Capital and Deep Technology: A Structural Mismatch

### 3.1 The Fund Lifecycle Problem

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Venture capital funds have a typical lifetime of 10 years: 3-5 years of deployment, 5-7 years of harvesting. The fund must return capital to limited partners within this window. This means that any investment must plausibly produce liquidity (IPO, acquisition) within 7-10 years of the initial investment.

Quantum computing --- even under the most optimistic scenarios --- does not fit this timeline:

- **Hardware companies** (IBM, Google, Rigetti, IonQ, PsiQuantum): The

development timeline for a fault-tolerant quantum computer of commercially useful scale is --- by the industry's own roadmaps --- 10-15 years from 2026. This means 20-25 years from the initial venture investments (circa 2015-2020). No VC fund has a 25-year horizon.

- **Software companies** (Zapata, QC Ware, 1QBit): The market for quantum

software does not exist because the hardware does not exist. Selling "quantum-inspired" classical algorithms to enterprises is a consulting business, not a software business. The margins and growth rates of consulting businesses do not justify venture-scale returns.

- **SaaS plays** (quantum cloud access): IBM, Amazon, and Microsoft offer

quantum computing as a cloud service. The revenue is negligible because the computational value is negligible. This is a marketing expense for the cloud providers, not a revenue-generating business.

The structural mismatch between VC timelines and quantum computing development timelines means that VC-funded quantum computing companies must either:

1. **Go public before they have revenue** --- as Rigetti, IonQ, and D-Wave

did via SPAC mergers. This transfers the risk from sophisticated venture investors to retail investors who cannot evaluate the technology.

1. **Pivot to a different business model** --- as many "quantum software"

companies have done, becoming classical AI/optimization consultancies.

1. **Perpetually raise more capital** --- extending the timeline beyond the

original fund's horizon through new funds, strategic investors, and government grants.

Option 1 is the most common and the most damaging: it creates publicly traded companies with no revenue, no product, and no plausible path to either, whose valuation is sustained by narrative rather than by fundamentals.

## 3.2 The Information Asymmetry Problem

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Venture capitalists --- with rare exceptions --- cannot evaluate quantum computing claims independently. They rely on:

- The prestige of the founding team (PhD from MIT, former IBM Quantum researcher).

- The prestige of the publication venue (*Nature*, *Science*, \*Physical Review Letters\*).

- The presence of other prestigious investors (if Sequoia or Andreessen Horowitz invested, it must be real).

- The narrative coherence of the pitch (does the story make sense to someone who does not understand quantum mechanics?).

None of these signals reliably predict technological success. They are all proxies for prestige --- and prestige, in quantum computing, is correlated with narrative production, not with computational output.

The information asymmetry between quantum computing entrepreneurs and their investors is not just large --- it is essentially unbridgeable. A VC partner with an MBA and an undergraduate engineering degree cannot, in a 30-minute pitch meeting, evaluate whether a company's claims about qubit coherence times, gate fidelities, and error-correction thresholds are credible. They must rely on heuristics. And those heuristics --- prestige, affiliation, narrative coherence --- select for the best storytellers, not the best physicists.

## 3.3 The Adverse Selection Cascade

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The information asymmetry creates an adverse selection problem: the entrepreneurs most likely to raise venture capital are not the ones most likely to build a working quantum computer, but the ones most skilled at navigating the prestige-heuristic evaluation process.

This selects for:

- Founders who are comfortable making ambitious claims without falsification criteria.

- Founders who have prestigious affiliations (which they may have acquired through the same narrative-production skills).

- Founders who can construct a compelling narrative that appeals to

investors' pattern-matching heuristics.

Over time, the pool of VC-funded quantum computing entrepreneurs is enriched for narrative skill and depleted for technical caution. The adverse selection cascade ensures that the companies that raise the most capital are the ones least likely to deliver on their claims --- because delivering on claims requires acknowledging uncertainty, qualifying timelines, and stating falsification criteria, all of which are penalized in the VC fundraising environment.

## 4. The Role of Government: What Works and What Doesn't

### 4.1 DARPA: The Gold Standard

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The Defense Advanced Research Projects Agency (DARPA) is widely --- and correctly --- regarded as the most successful government research funding agency in history. Its achievements include the internet (ARPANET), GPS, stealth technology, and the mRNA vaccine platform. DARPA's success is not accidental. It is a product of specific institutional design features:

- **Program managers with technical expertise and bounded terms.**

DARPA program managers are typically active researchers who serve for 3-5 years. They have the expertise to evaluate proposals technically and the limited tenure to avoid capture by the programs they fund.

- **Falsifiable milestones with go/no-go decisions.** DARPA programs are

structured around concrete, time-bound milestones. Programs that fail to meet milestones are terminated --- not extended, not refunded, not rebranded. This creates a hard selection pressure for honest evaluation.

- **Independence from commercial pressure.** DARPA funds research that is

"DARPA-hard" --- too risky for industry, too applied for basic science. Because DARPA does not seek commercial returns, it can fund research that a venture capitalist would reject.

- **Willingness to terminate.** DARPA kills programs. This is its most

important feature and the one most absent from other funding institutions. The willingness to terminate creates the incentive for honest evaluation: if you know your program will be killed when it fails, you have an incentive to define failure clearly and to report results honestly.

**Why DARPA has not prevented the quantum computing bubble:** DARPA's quantum computing investments are small relative to the total --- perhaps 200 — 300 *million over two decades, compared to* 35 billion globally. DARPA can fund rigorous research programs, but it cannot counterbalance the enormous capital flows from venture capital, corporate R&D, and international government programs that lack DARPA's institutional discipline.

### 4.2 The NSF and DOE: Dilution Without Discipline

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The National Science Foundation (NSF) and Department of Energy (DOE) fund quantum computing research at a larger scale than DARPA --- approximately \$1-2 billion cumulatively through the National Quantum Initiative and related programs. These agencies operate on a different model:

- **Peer review by the same community being funded.** NSF and DOE proposals

are reviewed by panels of academic researchers --- the same researchers who submit proposals. This creates a reciprocity dynamic: if I approve your proposal, you'll approve mine. The result is a high approval rate and low discrimination between proposals of varying quality.

- **No mechanism for post-award evaluation.** NSF and DOE grants are

evaluated based on the proposal, not on the results. Once a grant is awarded, there is no systematic mechanism for determining whether the research delivered on its promises. Failed grants do not affect future funding. Successful grants are not distinguished from unsuccessful ones.

- **Diffuse responsibility.** The NSF funds thousands of individual

investigators across hundreds of institutions. No single program manager is responsible for the overall portfolio's performance. Diffusion of responsibility eliminates the incentive for honest evaluation.

The result is that NSF and DOE funding for quantum computing has sustained a large academic research community without producing commercially relevant computational output. This is not a failure of individual researchers --- many of whom produce excellent science. It is a failure of the institutional design, which does not aggregate individual scientific contributions into a coherent program with falsifiable milestones.

### 4.3 International Comparison: The Chinese Model

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China is the world's largest public investor in quantum computing, with estimated cumulative investment of \$10-15 billion through national and provincial programs. The Chinese model has different strengths and weaknesses:

#### Strengths:

- Centralized coordination enables rapid scaling of successful approaches.
- Long time horizons (15-20 year national strategies) avoid the VC

timeline mismatch.

- Integration of research and manufacturing in state-owned enterprises

enables technology transfer that is difficult in market economies.

#### Weaknesses:

- Centralized coordination amplifies errors: if the central authority

backs the wrong technical approach, the entire national program follows.

- Absence of independent verification and public criticism: Chinese

quantum computing claims are not subject to the same adversarial scrutiny as Western claims, making it difficult to distinguish genuine progress from narrative production.

- Political pressure to demonstrate success: program managers have

incentives to report progress that may not reflect technical reality.

The Chinese model illustrates that government dominance of quantum computing R&D does not automatically solve the incentive problem. It changes the nature of the problem --- from market-driven narrative production to politically-driven narrative production --- but does not eliminate it.

## 5. Five Institutional Reforms

We propose five institutional reforms designed to align the incentive structure of post-classical computing R&D with the goal of producing actual computational output, not narrative assets.

## 5.1 Reform 1: An Advanced Computing Projects Agency (ACPA)

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**What:** A new government agency modeled on DARPA but focused exclusively on post-classical computing --- quantum, thermodynamic, neuromorphic, optical, reversible. The ACPA would have DARPA's institutional features: expert program managers with bounded terms, falsifiable milestones with go/no-go decisions, independence from commercial pressure, and a willingness to terminate failed programs.

**Why DARPA itself is insufficient:** DARPA's mandate spans all of defense technology. Quantum computing competes for attention with hypersonics, AI, biotech, and space. A dedicated agency would ensure sustained focus and expertise.

**Budget:** We estimate that an ACPA with an annual budget of \$500 million --- roughly the size of DARPA's information technology office --- could fund a diversified portfolio of post-classical computing research at a scale sufficient to explore the entire Problem-Substrate Mapping from Phase IV.

### Key design features:

- Program managers serve 3-5 year terms and are recruited from active researchers in relevant fields. They cannot serve consecutive terms.
- Every program has written, time-bound, falsifiable milestones.
- Programs that miss milestones are terminated. There is no appeal.
- All results --- positive and negative --- are published within 6 months of program completion. Negative results are celebrated as valuable contributions to knowledge.
- The ACPA does not commercialize technology. It funds research to the point of technology readiness, then transitions to industry or other government agencies for deployment.

## 5.2 Reform 2: Mandatory Independent Verification

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**What:** Any claim of quantum computational advantage above a materiality threshold --- defined as (a) claimed commercial relevance, or (b) funding above \$10 million from government sources, or (c) public claims of "quantum supremacy" or "quantum advantage" --- must be independently verified by a qualified third party that does not have a financial interest in the outcome.

### Independent verification protocol:

1. The claimant provides the independent verifier with access to the hardware (or, if hardware access is not feasible, with sufficient data and simulation specifications to reproduce the result classically).
1. The independent verifier conducts their own analysis and publishes their findings --- including any qualifications, limitations, or refutations --- within 6 months.
1. The independent verification report is linked to the original claim in a public registry.
1. Claims that are not submitted for independent verification within 12 months of the initial announcement are flagged as "unverified" in the registry.

**Funding:** Independent verification should be funded by a small levy on quantum computing research grants and investments (0.5% of total funding), pooled into an Independent Verification Fund administered by the ACPA or an equivalent institution.

**Enforcement:** For publicly funded research, compliance with independent verification is a condition of funding. For privately funded research, non-compliance is noted in the public registry. The market --- investors, customers, partners --- can then decide whether to engage with unverified claims.

### 5.3 Reform 3: Structural Separation of Hardware and Software

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**What:** Break the vertical integration of quantum computing companies, which control hardware, software, and cloud access. Require that any company receiving above \$50 million in government quantum computing funding divest either its hardware or its software/services division.

**Rationale:** Vertical integration creates a conflict of interest: the company that builds the hardware also evaluates the hardware's performance, develops the software that runs on it, and markets the cloud service that sells access to it. There is no point in this chain where independent evaluation can intervene. Structural separation creates a market for independent evaluation and benchmarking.

**Precedent:** The structural separation of telecommunications (AT&T breakup, 1984), banking (Glass-Steagall, 1933), and energy (PUHCA, 1935) demonstrates that structural separation can create competitive markets where vertical integration produced stagnation and rent-seeking.

**Implementation:** Existing companies would have 3 years to divest. New companies would be required to choose hardware or software from incorporation. The threshold (\$50 million in government funding) ensures that small startups are not burdened while the dominant players are restructured.

### 5.4 Reform 4: Joules-Per-Solution Procurement

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**What:** All government procurement of computational services --- including quantum computing --- must evaluate bids on a joules-per-solution basis for the specific problem being procured. "Joules per solution" means the total wall-plug energy consumed to deliver a verified, correct answer to the specified problem at the specified scale.

**Rationale:** The current procurement model allows quantum computing companies to sell "access" to hardware without demonstrating that the hardware solves any commercially relevant problem. A joules-per-solution requirement transforms procurement from a faith-based to an evidence-based process.

**Implementation:** For any computational procurement above \$1 million, the procuring agency must:

1. Specify the problem class, scale, and accuracy requirement.
2. Solicit bids that state the total energy consumption to deliver the

solution.

1. Evaluate bids based on total cost (energy + hardware + personnel),

with energy weighted at the agency's internal carbon price.

1. Publish the winning bid and its joules-per-solution for public review.

## 5.5 Reform 5: A Public Registry of Computational Claims

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**What:** A public, searchable, permanent registry of all claims of computational advantage or milestone achievement in post-classical computing, with mandatory time-bound falsification criteria.

**Registry fields:**

- Claim ID and date of announcement.
- Claimant institution and funding sources.
- Specific technical claim (not "quantum advantage" but "solving problem X of scale Y using Z joules in W seconds").
- Falsification criteria: what observation would constitute failure of the claim? By what date?
- Independent verification status (verified / refuted / qualified / unverified).
- Link to independent verification report.

**Effect:** The registry creates a permanent, public record that is difficult to ignore. A company that claims "quantum advantage" in 2025 and fails to demonstrate it by 2027 has a permanent entry in the registry noting the failure. This creates a reputational cost for failed claims that currently does not exist.

## 6. Objections and Implementation

### 6.1 "This Will Kill Innovation"

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**Objection:** Mandatory independent verification, structural separation, and joules-per-solution procurement will stifle innovation by imposing bureaucratic burdens on nimble startups.

**Response:** The current system is not producing innovation. It is producing narrative assets. \$35 billion over 20 years with zero commercially viable output is not "innovation." It is capital destruction dressed in the language of innovation.

Moreover, the reforms are designed to be light-touch for early-stage research and progressive for later-stage commercialization. The independent verification requirement applies only above a materiality threshold. The structural separation applies only above \$50 million in government funding. The joules-per-solution procurement applies only above \$1 million in procurement value. A two-person startup in a university lab would not be affected.

### 6.2 "The Market Will Sort It Out"

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**Objection:** The market --- investors, customers, the academic community --- will eventually distinguish genuine progress from narrative production. Government intervention is unnecessary and potentially harmful.

**Response:** The market has had 20 years and \$35 billion. It has not sorted it out. The information asymmetry between quantum computing entrepreneurs and investors is structural, not temporary. The prestige cascade in academic publishing is self-reinforcing. The regulatory vacuum is deliberate. None of these features will self-correct.

The appropriate analogy is not "innovation" but "financial regulation." Securities markets required the SEC because information asymmetry between issuers and investors is structural. Drug markets required the FDA because information asymmetry between manufacturers and patients is structural. Quantum computing requires similar institutional infrastructure because information asymmetry between claimants and funders is structural.

### 6.3 "International Competition"

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**Objection:** If the United States imposes these reforms unilaterally, China and Europe will gain a competitive advantage by operating without regulatory burden.

**Response:** If the reforms prevent capital from flowing to narrative production and redirect it toward actual computation, the United States will GAIN a competitive advantage --- because its capital will be productively deployed while competitors' capital will be consumed by the narrative production function.

Moreover, the reforms should be pursued through international coordination --- through the OECD, the G7, and bilateral science and technology agreements. The quantum computing bubble is a global phenomenon, and its correction should be global.

## 7. Conclusion: Institutional Honesty

The first four papers in this series have argued that quantum computing's failure is epistemic, that alternatives exist, that physical limits matter, and that a diversified investment portfolio is the rational response. This paper has argued that none of these insights will be acted upon without institutional reform --- because the current institutional structure systematically rewards narrative production over computational output.

The five reforms we propose --- an Advanced Computing Projects Agency, mandatory independent verification, structural separation of hardware and software, joules-per-solution procurement, and a public registry of computational claims --- are designed to realign the incentive structure of post-classical computing with the goal of producing actual computation, not just press releases, patents, and valuations.

These reforms are not radical. They are modeled on institutions that already exist and have proven effective: DARPA, the FDA, the SEC, the NIH clinical trials registry. What is radical is only the proposal to *apply* these institutional forms to a domain that has, so far, been exempt from the ordinary requirements of evidence, verification, and accountability.

The alternative to institutional reform is not the status quo. The status quo is a machine for converting public and private capital into narrative assets. The alternative to reform is the continuation of this machine --- another \$35 billion, another two decades, another round of "quantum supremacy" announcements followed by quiet qualifications. The laws of physics do not negotiate. Neither should the institutions that fund the effort to understand them.

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