THE MISSING MIDDLE

HOW TO CLOSE AMERICA'S DEEP-TECH FINANCING GAP IN STRATEGIC COMPETITION WITH CHINA

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The Missing Middle: How to Close America's Deep-Tech Financing Gap in Strategic Competition with China

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Any errors or omissions remain the responsibility of the author.

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The United States and China are locked in competition to finance and deploy foundational technologies—advanced semiconductors, batteries, quantum computers, AI accelerators—that will underwrite economic leadership and ensure national security for decades. While America maintains leadership in breakthrough innovation, China has built the world's largest state capital apparatus to capture manufacturing dominance in strategic sectors.

America's Missing Middle Gap

American deep-tech companies excel at raising early-stage capital (such as the first $20 million to prove technology works) and late-stage financing (once operations are established), but face a systematic gap at the critical transition stage: the $50-$300 million needed to build first-of-a-kind commercial facilities. This is where laboratory prototypes must become manufacturable products, and where American companies repeatedly lose to Chinese competitors.

While U.S. companies spend 18 months navigating fragmented financing options, Chinese competitors access integrated state capital—policy banks providing patient financing at concessional rates with rapid approvals that enable faster market entry. The result: Chinese firms now control 76% of global lithium-ion battery production and 80%+ of solar panel manufacturing, despite American leadership in the early-stage research and prototyping that created these technologies. This reflects a systematic pattern: U.S. innovation discovers and validates breakthrough technologies; Chinese integrated capital captures their manufacturing scale-up.

China's Bifurcated System

China's deep-tech financing reveals both strengths and critical weaknesses. Policy banks effectively deploy patient capital for manufacturing scale-up in mature technologies. But the broader system suffers from political paralysis—the $47.5 billion semiconductor "Big Fund" was frozen for five months during 2022 corruption investigations. Of 2,107 government guidance funds totaling $940 billion, 66% of these funds have not made any investments. Top-tier venture capitalists now actively avoid government capital despite its availability.

Four Mechanisms to Win

This report identifies four targeted mechanisms to close America's missing middle gap without replicating Chinese dysfunction:

- **Patient Capital at Scale:** $50 to 100 billion loan guarantee facility enabling 15-year financing at sub-3 percent rates for first-of-a-kind manufacturing, generating 5 to 10 times the private capital leverage
- **Speed and Commitment Credibility:** Six-month statutory approval deadlines with commitment protection, ending the uncertainty that currently paralyzes company planning
- **Demand-Side Coordination:** $20 to 30 billion in advanced purchase commitments across the Defense Department, Department of Energy, and General Services Administration, removing revenue risk and unlocking 10 to 20 times private investment leverage
- **Technology Maturity Demonstration:** $500 million to $1 billion annual program for targeted grants ($10 million to $50 million each) proving technology readiness at critical inflection points

These mechanisms preserve venture capital's strengths at financing early-stage, risky technologies while addressing specific gaps venture capital cannot fill. Success requires partnership without control—letting private investors identify technologies while public capital provides patient financing, credible demand signals, and maturity validation that unlock substantially larger private capital flows.

The Strategic Opportunity

China has shown the missing middle can be addressed with state capital. America must address this challenge more efficiently–combining venture dynamism with patient capital, achieving coordination without centralization, and demonstrating that partnership outperforms control. Four mechanisms merit policymakers' immediate attention. Implementation will determine whether American innovation translates to manufacturing leadership or Chinese integrated capital continues capturing the commanding heights of strategic technology sectors.

Introduction

In the joint report of their visit to China in 1972, House Majority Leader Hale Boggs and then-Minority Leader Gerald Ford wrote: "If she manages to achieve as she aspires, China in the next half century can emerge a self-sufficient power of a billion people… This last impression, of the reality of China's colossal potential, is perhaps the most vivid of our journey. As our small party traveled through that boundless land, this sense of a giant stirring, a dragon waking, gave us much to ponder."[1] It is now more than fifty years later, and those ponderings have materialized into the defining strategic challenge of the twenty-first century.

The United States and China are locked in decisive competition to finance, scale, and deploy the foundational technologies that will determine global economic leadership and national security superiority for decades to come. As Attorney General William Barr warned in 2020, the People's Republic of China is "engaged in an economic blitzkrieg: an aggressive, orchestrated, whole-of-government campaign to seize the commanding heights of the global economy and to surpass the United States as the world's preeminent superpower."[2]

While advancements in Artificial Intelligence (AI) dominate the zeitgeist, another battleground is hardware-intensive deep technology: advanced semiconductors, battery systems, quantum computers, AI accelerators, and next-generation manufacturing equipment. These are not abstract innovations but the strategic high ground that determines which nation builds the weapons systems, autonomous platforms, and infrastructure of tomorrow. While the United States maintains leadership in venture capital and breakthrough innovation, China has constructed the world's largest state capital apparatus specifically designed to capture manufacturing dominance in these strategic domains.

Between American venture capital's funding of early stage innovation and infrastructure investors' late-stage financing lies a systematic gap that is costing the United States its manufacturing leadership. Deep-tech companies can raise $20 million to prove their science works but struggle to raise the $50 million to $300 million needed to build first-of-a-kind commercial facilities (i.e., the stage where laboratory prototypes must become manufacturable products). This "missing middle" is where hardware-intensive innovation dies in America, even when the underlying technology is sound. It is also where China is winning.

1 Hale Boggs & Gerald R. Ford, "Impressions of the New China," H.R. Doc. No. 92-337, at 3 (1972), https://www.fordlibrarymuseum.gov/library/document/0358/035800376.pdf.

2 William P. Barr, "Attorney General William P. Barr Delivers Remarks on China Policy at the Gerald R. Ford Presidential Museum," U.S. Department of Justice, July 16, 2020, https://www.justice.gov/archives/opa/speech/transcript-attorney-general-barr-s-remarks-china-policy-gerald-r-ford-presidential-museum.

The pattern repeats across sectors with devastating consistency. While American companies spend eighteen months seeking to raise financing from disparate sources, Chinese competitors leverage integrated state capital—coordinated deployment across policy banks, government funds, and subsidies—to reach commercial scale faster, establish market position, set price points, and capture customers. Chinese companies now control 76 percent of global lithium-ion battery production.[3] Beijing raised $47.5 billion for its third national semiconductor fund in 2024 alone.[4] Solar panel production shifted 80+ percent to China,[5] despite the fact that American researchers and companies pioneered the fundamental breakthroughs in photovoltaic technology. This is a pattern where U.S. innovation creates technologies that Chinese manufacturing dominance then captures.

The urgency extends beyond competitive disadvantage. As former FBI Director Christopher Wray has documented, China's military and intelligence services systematically steal American intellectual property through cyber espionage, forced technology transfers, and talent recruitment—what he characterized as "Chinese theft on a scale so massive that it represents one of the largest transfers of wealth in human history."[6] The missing middle financing gap compounds this vulnerability: by the time American companies navigate fundraising obstacles, Chinese competitors have already replicated stolen technologies and scaled production through integrated state capital.

This report argues that venture capital remains necessary but insufficient for hardware scale-up, and that the binding constraint operates precisely at the demonstration and pilot production stage—when companies must construct their first commercial-scale facility. At this 'first-of-a-kind facility' stage, neither venture capital nor federal programs currently function effectively. The strategic answer is not to replicate China's state-directed model but to achieve superior integration through partnership, by combining venture capital's innovation discovery strengths with public capital's scale and patience. This can be done while preserving the dynamism and market discipline that generate breakthrough technologies in the first place.

Understanding China's approach provides strategic insight into competitive advantage in hardware sectors. Beijing's integrated financing architecture demonstrates that coordinated capital deployment across the full commercialization pathway delivers results. Yet it equally demonstrates that effective integration need not require centralization or state control.

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3 International Energy Agency, "Trends in Electric Vehicle Batteries," Global EV Outlook 2024, https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-vehicle-batteries.

4 Qin Min and Han Wei, "China Piles $47.5 Billion Into 'Big Fund III' to Boost Chip Development," *Caixin Global*, May 28, 2024, https://www.caixinglobal.com/2024-05-28/china-piles-475-billion-into-big-fund-iii-to-boost-chip-development-102200633.html.

5 International Energy Agency, "Solar PV Global Supply Chains," Special Report, July 2022, https://www.iea.org/reports/solar-pv-global-supply-chains.

6 Christopher A. Wray, "The Threat Posed by the Chinese Government and the Chinese Communist Party to the Economic and National Security of the United States," Federal Bureau of Investigation, July 7, 2020, https://www.fbi.gov/news/speeches/the-threat-posed-by-the-chinese-government-and-the-chinese-communist-party-to-the-economic-and-national-security-of-the-united-states.

America has an opportunity to design public-private partnerships that deliver coordination without political control, scale without rigidity, and patience without the corruption and misallocation that plague China's system.

This report proceeds in three parts. **Part I** maps the American deep-tech investment landscape in detail, documenting how capital flows through the innovation system, examining the specialized venture firms that have emerged to finance hardware, and explaining precisely why even these sophisticated investors encounter structural limits at the first-of-a-kind facility stage. **Part II** examines China's deep-tech financing ecosystem, distinguishing between instruments that function effectively and those that fail systematically. **Part III** synthesizes strategic lessons from both systems, identifying four specific mechanisms where targeted American public-private partnerships can close the missing middle gap while preserving the very advantages in innovation that China's state-directed model suppresses.

Methodology

This report builds on prior work of the Institute for Security and Technology's Strategic Balancing Initiative and serves as a companion analysis to Michael Brown's and Pavneet Singh's report, "Why Venture Capital is Indispensable for U.S. Industrial Strategy". While that earlier work examined how to align venture capital incentives with national technology priorities across the full innovation pipeline, this report focuses specifically on the systematic financing gap at the missing middle stage where hardware-intensive technologies transition from prototype to commercial manufacturing.

United States Analysis

We leveraged IST's extensive networks in Silicon Valley to conduct in-depth interviews with ten venture capital firms actively investing in deep-tech hardware sectors, including batteries, semiconductors, and advanced materials. Firms were selected based on fund size exceeding $500 million, demonstrated track record in capital-intensive hardware investments, and portfolio companies that have attempted first-of-a-kind manufacturing facilities. Interviews were conducted between April and September 2025. To enable candid discussion of market dynamics, investment decision-making, and policy gaps, neither the interview subjects nor their affiliated firms are identified in this report.

In early 2025, IST also convened a roundtable involving members and staff of the House Select Committee on the Strategic Competition Between the United States and the Chinese Communist Party and Silicon Valley venture capital investors to discuss comparative financing dynamics.

Quantitative data on U.S. venture capital flows, deal sizes, and sector allocations were sourced from Crunchbase and publicly available filings. Federal program data were obtained from agency reports, Congressional Research Service analyses, and public disclosures.

China Analysis

China's deep-tech financing architecture presented greater methodological challenges due to limited transparency and blurred boundaries between private investment and state coordination. We relied on three primary sources: (1) peer-reviewed academic research with access to Chinese-language policy documents; (2) reporting by specialized outlets covering Chinese technology policy (e.g., South China Morning Post, Caixin Global); and (3) interviews with experts on Chinese venture capital ecosystems, including investors who operated funds in China and policy analysts tracking industrial policy. We triangulated sources where possible, but acknowledge inherent limitations in analyzing opaque financing structures. Where uncertainty exists, we provide ranges rather than precise estimates and note limitations in the analysis.

Part I: The American Deep-Tech Investment Landscape

How Money Moves Through the U.S. Innovation System

The American approach to financing technological innovation follows a well-established pathway—one well-designed for software, but fundamentally mismatched to hardware-intensive deep technology. Federal research funding begins the journey with approximately $200 billion annually in R&D investment, including roughly $50 billion in basic research and $50 billion in applied research across agencies.[7] The National Science Foundation (NSF), U.S. Department of Energy (DOE), Department of War (formerly Department of Defense (DOD)) labs and National Institutes of Health (NIH) support fundamental science at universities and national laboratories, and defense research facilities.[8] Small Business Innovation Research (SBIR) bridges early commercialization with Phase I grants ($150,000) to prove feasibility and

7 Lisa Benson, Marcy Gallo, Laurie Harris, Angela Jones, Kavya Sekar, and Jared Sussman, Congressional Research Service, "Federal Research and Development (R&D) Funding: FY2025," Report R47564, updated January 2, 2025, https://crsreports.congress.gov/product/pdf/R/R47564.

8 National Science Foundation, Department of Energy, and National Institutes of Health combined annual R&D appropriations, FY2024 Budget. See https://www.nsf.gov/about/budget/, https://www.energy.gov/cfo/budget, https://www.nih.gov/about-nih/what-we-do/budget.

Phase II grants (up to $2 million) to develop prototypes.[9] Venture capital enters next: Seed funds typically provide $500,000 to $5 million for initial prototypes, while Series A investors typically deploy $10 million to $30 million once companies demonstrate product-market fit. For software businesses, this works smoothly: a team can reach profitability with $20 million total and generate the ten-times returns that venture investors require. Growth equity and infrastructure investors complete the pathway, but only for companies with proven operations and steady cash flows.

A specialized cohort of venture firms has emerged to finance deep-tech hardware. For instance, Andreessen Horowitz launched its $600 million American Dynamism fund explicitly to compete with China in strategic technologies. Breakthrough Energy Ventures operates with twenty-year fund lifecycles to provide patient capital hardware companies require, having raised over $3 billion across three funds. DCVC employs computation-driven investment approaches for quantum computing and AI infrastructure, managing billions in assets. Lux Capital manages over $5 billion in assets focused on frontier science and emerging technologies. Major financial institutions and technology companies have announced significant domestic manufacturing commitments, signaling corporate recognition of reshoring imperatives: JPMorganChase launched a $1.5 trillion Security and Resiliency Initiative over ten years, including $10 billion in direct equity investments targeting supply chain resilience and advanced manufacturing,[10] and Apple committed $600 billion over four years through its American Manufacturing Program to expand domestic semiconductor and component production.[11] However, corporate commitments typically flow to established suppliers with proven operations, not companies building first-of-a-kind facilities—the same gap venture capital struggles to address. Combined, leading deep-tech venture firms manage a large amount of capital, employ PhD-level technical partners, and have backed breakthrough companies from early prototypes through commercial deployment. Yet even

Yet even these best-resourced investors encounter structural limits that stem not from lack of expertise or risk tolerance, but from fundamental mismatches between fund structures and hardware manufacturing requirements.

9 Andrew Tilghman, Congressional Research Service, "Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs," R44710, January 2023, https://crsreports.congress.gov/product/pdf/R/R44710.

10 "JPMorganChase Launches $1.5 Trillion Security and Resiliency Initiative to Boost Critical Industries," press release, JPMorganChase, October 13, 2025, https://www.jpmorganchase.com/newsroom/press-releases/2025/jpmc-security-resiliency-initiative.

11 White House, "Apple's $600 Billion Commitment to Boost U.S. Manufacturing," August 7, 2025, https://www.whitehouse.gov/articles/2025/08/apple-600-billion-commitment-to-boost-u-s-manufacturing/.

these best-resourced investors encounter structural limits that stem not from lack of expertise or risk tolerance, but from fundamental mismatches between fund structures and hardware manufacturing requirements.

***Appendix A* provides a detailed breakdown of the top ten deep-tech venture funds identified by our research team and their assets under management.**

Why Venture Capital Hits Structural Limits

The Ten-Year Clock

Venture funds operate as limited partnerships with defined lifecycles: invest capital in years one through four, grow portfolio companies in years four through seven, and generate exits through acquisition or IPO in years seven through ten.[12] Software companies reaching scale in three to five years fit naturally within this timeline. Deep-tech hardware companies requiring ten to fifteen years from technical validation through commercial manufacturing do not. Boston Consulting Group found deep-tech companies take 25 to 40 percent longer than software startups to reach the same milestones.[13] Similarly, Bessemer Venture Partners tracked top-performing deep-tech companies requiring an average of 9.2 years to reach scale, raising $800 million, and achieving $4 billion valuations, fundamentally different unit economics than the software world that has shaped modern venture capital fund structures.[14]

The battery manufacturing company QuantumScape illustrates the timeline challenge. Founded in 2010 to develop solid-state batteries, the company spent a decade on R&D before demonstrating viable prototypes in late 2020. Rather than navigating traditional venture fundraising for manufacturing scale-up, QuantumScape merged with special purpose acquisition company (SPAC) Kensington Capital in November 2020, receiving $1 billion enabling pilot production development. By 2024, fourteen years after its founding, QuantumScape had raised over $1 billion in venture capital but remained pre-revenue, with commercial production still years away.[15] This timeline starkly illustrates venture capital's structural challenge: the company's development arc far exceeds typical VC fund cycles, creating persistent pressure for liquidity that conflicts with the patient capital requirements of solid-state battery commercialization. QuantumScape found a workaround through a 2020

12 Paul Gompers and Josh Lerner, *The Venture Capital Cycle*, 2nd ed. (Cambridge: MIT Press, 2004), 149–82.

13 Antoine Gourévitch, Massimo Portincaso, Arnaud de la Tour, Nicolas Goeldel, and Usman Chaudhry, "Deep Tech: The Great Wave of Innovation," Boston Consulting Group, September 2021, https://www.bcg.com/publications/2021/deep-tech-innovation.

14 David Cowen, "The Rise of Deep Tech: Investing in Science and Engineering-Intensive Innovation," Bessemer Venture Partners, April 2023, https://www.bvp.com/atlas/roadmap-deep-tech.

15 Tracxn, "QuantumScape — Funding Rounds & List of Investors," Tracxn, accessed October 20, 2025, https://tracxn.com/d/companies/quantumscape/__BfDAmXiv4rJeuFRhv5-SVqpK-CLftUrn9okZuh6UPHA/funding-and-investors.

SPAC merger that provided over $700 million in additional growth capital and early liquidity for investors, but this solution represented special circumstances rather than a replicable model.[16] The widespread SPAC availability that QuantumScape accessed proved temporary, leaving many subsequent deep-tech companies without this option during the critical 2022-2024 period, extending their time in the funding valley and delaying commercialization efforts precisely when patient capital was most needed for pilot production and manufacturing scale-up.[17]

Capital Intensity

Software companies might deploy a $15-20 million Series A primarily toward engineering salaries and cloud computing costs, typically reaching $2-$5 million in annual recurring revenue within 18-24 months—enough to pursue a Series B. Deep-tech hardware companies at comparable technical maturity need $50 million to $300 million just to construct pilot production lines and demonstrate manufacturing feasibility. Then, they need another several hundred million to multi-billion dollars for first commercial-scale factories before they are able to generate meaningful revenue, a process that can take 5-10 years from initial funding.

An investor explained the challenge, observing that a software company raising $2 million to $5 million in Series A with revenue traction is an attractive investment story for venture capital firms. On the other hand, they noted, a deep-tech company seeking $50 million for a first-of-a-kind facility without revenue is a fundamentally different risk profile that most venture firms cannot accommodate. The capital requirements exceed what early-stage funds can deploy, while the absence of revenue makes growth investors uncomfortable, especially in light of the more efficient access to profits posed by software companies.[18]

The Risk Perception Shift

At Seed and Series A stages, investors evaluate technical risk: Does the science work? Can the team build a functioning prototype? Venture capitalists feel competent assessing these questions through scientific advisors and technical due diligence. When companies need to construct first commercial factories, however, risk fundamentally transforms into questions of project management and manufacturing execution: can construction be completed on time and budget? Will manufacturing yields meet targets? Can supply chains be secured?

16 Kirsten Korosec, "Volkswagen-backed QuantumScape to Go Public via SPAC to Bring Solid-State Batteries to EVs," TechCrunch, September 3, 2020, https://techcrunch.com/2020/09/03/vw-backed-quantumscape/.

17 Scooter Doll, "QuantumScape's Q2 Report Reveals 10-Layer Solid-State Battery, Plus Commercialization Timeline," Electrek, July 27, 2021, https://electrek.co/2021/07/27/quantumscapes-q2-report-reveals-10-layer-solid-state-battery-plus-commercialization-timeline/.

18 Institute for Security and Technology, interviews with deep-tech venture capital investors and operators, 2025 (anonymized per interviewee requests).

How quickly can cost competitiveness against established manufacturers with decades of optimization be achieved?

These are domains where most venture investors lack deep experience. Eighty-one percent of deep-tech companies report that investors lack the scientific and engineering background to properly assess their opportunities.[19] The manufacturing knowledge gap compounds this problem. One investor described needing a “sixth sense” for manufacturing, like understanding lead times for hundreds of components, knowing which suppliers can deliver custom parts at scale, and recognizing which design choices will create bottlenecks months down the road. For example, a founder we interviewed who spent years visiting Chinese manufacturing facilities dozens of times developed this intuition. However, they said, “most PhD scientists starting deep-tech companies do not possess it, and there are not enough people in the United States who do.”[20]

Figure 1: Deep-Tech Investment Risk-Return Perception Across Company Stage

	Seed	Series A	Series B / Pilot	Growth / FOAK	Late / Scale
Capital Availability	High	High	Moderate	Low	High
Perceived Risk-Return	Favorable high risk, high return	Favorable technical risk, huge upside	Marginal capital increases, technical de-risked	Unfavorable massive capital, execution risk, uncertain returns	Favorable proven operations, predictable returns

Note: Synthesized from interviews with leading deep-tech investors conducted by the Institute for Security and Technology, April-September 2025

Empirical Validation

Our data analysis confirms this gap. We sampled 1,098 deep-tech companies across five strategic hardware sectors—semiconductors, battery technology, quantum computing, advanced manufacturing, and robotics—using Crunchbase data from 2020 through 2024. For each company, we tracked funding amounts and rounds across development stages: Pre-Seed, Seed, Series A, Series B, and Growth (Series C+).

19 Deep Tech Alliance survey data, cited in “State of Deep Tech Investment 2024,” https://www.deeptechalliance.org.

20 Institute for Security and Technology, interviews with deep-tech venture capital investors and operators, 2025 (anonymized per interviewee requests).

The data validates precisely what investors described in our interviews: capital flows abundantly at early stages, then constricts dramatically at the scale-up phase where companies must prove manufacturing viability. From 2020 through 2024, Seed-stage funding totaled $2.04 billion across 357 deals, while Series A reached $8.48 billion across 294 deals, demonstrating robust early-stage capital availability. But at Series B, where companies typically need to build first-of-a-kind facilities, deal count drops to 205 (a 30% decline from Series A) even as average deal size nearly doubles from $28.8 million to $51.9 million.

The valley becomes a chasm at later stages. Growth-stage funding (Series C and beyond) involved only 184 deals with an average deal size of $370 million, seven times larger than Series A rounds. This dramatic escalation in capital requirements, combined with steadily declining deal counts, creates the structural bottleneck our investor interviews identified: companies reaching technical validation can raise $20-30 million for prototypes, but struggle to assemble the $50-300 million needed for commercial-scale manufacturing facilities.

The chart below illustrates this funding valley. Blue columns show deal volume declining from 357 Seed deals to 205 Series B deals to 184 Growth-stage deals. The black line tracks average deal size climbing from $5.7 million at Seed to $51.9 million at Series B, then spiking to $370 million for Growth stage. This empirical pattern reveals why existing federal programs, despite massive expansion, fail to close the gap. Early-stage programs like the Small Business Innovation Research (SBIR) program,[21] and the Advanced Research Projects Agency-Energy (ARPA-E),[22] effectively support Seed and Series A stages where capital already flows robustly—357 Seed deals and 294 Series A deals demonstrate these stages function well. Late-stage programs like DOE Loan Programs Office and CHIPS Act manufacturing incentives target Growth-stage companies with proven operations. But Series B—where deal count drops 30% and capital requirements nearly double—receives no targeted federal support. Federal programs remain structured around a binary framework: early-stage R&D grants for technology development, and late-stage deployment incentives for proven, scalable projects. This architecture systematically excludes the intermediate stage where companies must demonstrate manufacturing viability before they can access deployment capital. The missing middle emerges not from insufficient government spending generally, but from program architecture that creates a systematic gap at the demonstration and pilot production stage. This gap appears precisely where it matters most: between 2020 and 2024, 205 companies attempted to prove manufacturing viability at this stage, yet no federal program specifically targets their capital needs.

21 U.S. Small Business Administration, "Small Business Innovation Research (SBIR) Program," SBIR.gov, accessed October 28, 2025, https://www.sbir.gov/.

22 ARPA-E, "Advanced Research Projects Agency–Energy (ARPA-E)," ARPA-E, accessed October 28, 2025, https://arpa-e.energy.gov/.

Figure 2: The Missing Middle: Number of Deals and Average Deal Size

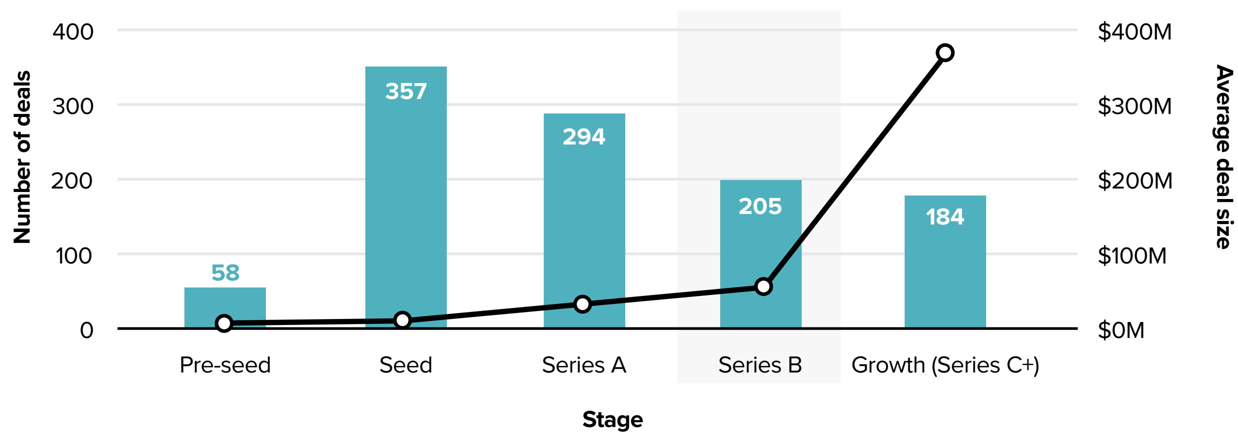
Number of deals — Average deal size (USD)

Key findings:

- » The Missing Middle Emerges at Series B
- » Capital Requirements Spike at Growth Stage
- » Series B Deal Activity **Declined 24%** from 2023 to 2024
- » Early-Stage Capital Remains Abundant
- » Growth Stage Concentration

Total funding (USD)

Pre-Seed	$150.4M
Seed	$2043.51B
Series A	$8478.86B
Series B	$10630.21B
Growth (Series C+)	$68136.39B



See: Appendix B for more information

The AI Infrastructure Exception

AI infrastructure stands out as a striking exception to the "missing middle" pattern. The sector has attracted extraordinary levels of capital and valuation growth, reflecting an investment dynamic fundamentally distinct from the rest of the deep-tech landscape. Leading AI labs have raised multi-billion dollar funding rounds, while national commitments to build data centers and expand computing capacity have mobilized tens of billions in additional capital. This means that when AI companies need large amounts of money to scale—whether for training infrastructure, compute capacity, or deployment—investors are ready to provide it. The capital-intensive nature of AI development, rather than deterring investment, has attracted it.

Three factors explain why AI infrastructure breaks the rule.

» **Demand certainty:** the market demand for AI capabilities has been validated through rapid enterprise adoption and willingness to pay, creating investor confidence in future revenue potential that most deep-tech ventures cannot yet demonstrate.

» **Asset bankability:** data centers, power systems, and AI accelerators are underpinned by mature project finance models, making them familiar to institutional investors in ways that novel manufacturing processes are not.

» **Strategic clarity:** the national security relevance of compute capacity has catalyzed public-private alignment, where government endorsement and corporate capital reinforce each other rather than waiting on sequential risk transfer.

This anomaly underscores, rather than contradicts, the structural problem at the heart of U.S. deep-tech finance. Capital flows easily when markets are proven, assets are legible, and national interest is uncontested. By contrast, most hardware-intensive innovations—advanced materials, next-generation batteries, semiconductor tools—occupy the uncertain transition zone between proof-of-concept and scale. In those cases, the combination of high technical risk and unclear demand continues to strand promising technologies in the missing middle that AI infrastructure so conspicuously avoids.

The Private Equity and Project Finance Gap

Private equity firms and project finance banks should theoretically fill the missing middle: as one interviewee pointed out, "they write $50-200M checks routinely and finance large-scale infrastructure projects as core business." Private infrastructure assets under management reached $1.3 trillion by June 2024, with data center investments alone surging to $50 billion in 2024, up from $11 billion in 2020.[23] Major private equity firms, including Blackstone ($1.27 trillion AUM), KKR ($638 billion AUM), and Apollo ($785 billion AUM), command enormous capital specifically targeting infrastructure and manufacturing investments. Project finance banks structure billion-dollar deals for power plants, manufacturing facilities, and transportation infrastructure globally. Yet our interviews revealed repeated reluctance to finance first-of-a-kind deep-tech facilities, despite their clear strategic importance.

The mismatch stems from fundamental investment criteria rather than capital scarcity. Private equity firms typically target companies with "proven business models" and established revenue streams, relying on EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization) multiples or revenue multiples for valuations—valuation methods that depend on established operating cash flows.[24] First-of-a-kind (FOAK) facilities, which are the initial commercial-scale manufacturing plants needed to transition from prototype to production, face a distinct challenge. These facilities have validated technology but lack the operating history and cash flow predictability that private equity valuation approaches require. Project finance lenders require three conditions that first-of-a-kind facilities cannot simultaneously provide: validated technology, demonstrated technical readiness, and proven operating history. Infrastructure investors seek specific risk-return profiles with narrow parameters—projects targeting 1.25x–1.35x debt service coverage ratios, contracted cash flows, and long-term purchase agreements or offtake contracts that guarantee revenue streams.[25]

This creates a paradox where the capital exists but cannot flow to the critical transition stage. Private equity firms invested record amounts in AI-related infrastructure because demand certainty, proven technology, and bankable assets aligned with their investment criteria. Data centers secured $50 billion in 2024[26] precisely because major tech companies (hyperscalers like Google, Microsoft, and Amazon) made long-term commitments that created revenue visibility, and because the underlying technology—power systems, cooling infrastructure, fiber connectivity—represented mature, well-understood risk. Both the facilities themselves and the digital infrastructure they house attracted capital because the technology was proven and demand was secured. First-of-a-kind deep-tech manufacturing facilities occupy the opposite position: they embody breakthrough technology that still awaits commercial validation, require significant capital before generating revenue, and present execution risks that

23 "Private Equity Infrastructure Investment Poised for Renewed Growth Amid Evolving Market Dynamics," press release, Boston Consulting Group, March 17, 2025, https://www.prnewswire.com/news-releases/private-equity-infrastructure-investment-poised-for-renewed-growth-amid-evolving-market-dynamics-302402317.html.

24 Shaheer Ansari, "Top Technology Private Equity Investors Shaping the Future of Tech," Aventis Advisors, August 14, 2025, https://aventis-advisors.com/list-of-top-technology-private-equity-investors/.

25 New Energy Risk, "Industrial & Energy Technology Project Finance," November 2021, https://newenergyrisk.com/wp-content/uploads/2021/11/NER-Project-Finance-Guide.pdf.

26 Rhys Northwood, "Private Equity's Strategic Domination in the AI-Driven Data Center Consolidation," AInvest, October 2, 2025, https://www.ainvest.com/news/private-equity-strategic-domination-ai-driven-data-center-consolidation-2510/.

traditional project finance structures are not designed to handle. The contrast is stark: proven infrastructure attracts abundant capital, while the first commercial-scale facilities for strategic technologies remain unfunded, even as these are precisely the assets American companies need to compete with Chinese state-backed competitors.

Recent developments signal growing private equity interest in manufacturing and infrastructure, but have not yet bridged the first-of-a-kind gap. Indeed, private firms are increasingly targeting infrastructure. General Atlantic acquired UK-based Actis and its $12.5 billion sustainable infrastructure platform, while CVC acquired a majority stake in DIF Capital Partners focusing on mid-market infrastructure, including energy transition capabilities.[27] The Inflation Reduction Act's tax incentives created heightened interest in renewable energy and clean technology manufacturing. However, capital deployment based on these tax incentives concentrates in later-stage facilities with proven operations rather than first-of-a-kind transitions.

What would unlock private equity and project finance capital for first-of-a-kind facilities? **Part III** of this report identifies four mechanisms specifically designed to convert first-of-a-kind projects into investments that match private equity risk-return requirements.

The goal is not replacing private capital with public capital, but catalyzing it by using targeted public instruments to make first-of-a-kind facilities financeable by the private equity and project finance institutions that already write large checks for infrastructure investments. When these mechanisms reduce downside risk, provide revenue certainty, prove technology readiness, and operate predictably, first-of-a-kind facilities begin to resemble the proven infrastructure investments that private equity firms have already deployed $1.3 trillion to finance. The capital exists, but we need the mechanisms to make it accessible.

Federal Programs Miss the Critical Stage

The federal government dramatically expanded deep-tech support from 2020 through 2025: the CHIPS Act allocated $39 billion for semiconductor manufacturing, the Inflation Reduction Act appropriated hundreds of billions for clean energy, and the Department of Energy's Loan Programs Office issued over $400 billion in loans.[28] Despite this scale, federal programs miss the missing middle stage where companies transition from validated prototypes to operating

27 Luke Laumann, Tim Sheddick, and Caroline Sherrell, "PE firms increasingly target infrastructure," M&A Explorer, White & Case, June 11, 2024, https://mergers.whitecase.com/highlights/pe-firms-increasingly-target-infrastructure.

28 U.S. Government Accountability Office, "DOE Loan Programs: Actions Needed to Address Loan Authority and Improve Application Reviews," GAO-25-106631, December 2024, https://www.gao.gov/products/gao-25-106631; CHIPS and Science Act of 2022, Pub. L. No. 117-167, § 103.

manufacturing facilities. One investor we talked to likened federal support to bookends with nothing in the middle.[29]

Early-Stage Support Works

The Small Business Innovation Research (SBIR) program and Small Business Technology Transfer (STTR)[30] program—which facilitates research partnerships between small businesses and research institutions—distribute approximately $4 billion annually across eleven federal agencies for early-stage technology development. ARPA-E has provided over $3.6 billion since 2009 for high-risk energy technologies, typically $1 million to $10 million per project.[31] These programs operate non-dilutively, demonstrate genuine risk tolerance, and prove helpful for companies proving new technologies work at laboratory and prototype scale.

The programs succeed because they explicitly target technical risk at early stages. For example, ARPA-E's model, which allows program managers with deep scientific expertise to make rapid decisions on transformational concepts, has generated commercialization success rates exceeding traditional grant programs. But Phase II SBIR grants end at approximately $2 million, and ARPA-E projects typically conclude at $10 million. For a company graduating from a successful ARPA-E award and needing $100 million to construct its first commercial production facility, the early-stage "bookend" is not sufficient to bridge the missing middle.

Late-Stage Support Requires Established Operations

DOE's Loan Programs Office holds over $400 billion in loan authority and has financed transformative projects.[32] The CHIPS Act allocated $39 billion for semiconductor manufacturing incentives, with major awards to Intel ($7.865 billion), TSMC ($6.6 billion), Samsung ($6.4 billion), and Micron ($6.1 billion) for manufacturing expansion.[33] These four companies alone received approximately 69 percent of allocated CHIPS manufacturing funds, resources directed toward established global manufacturers with proven production capabilities rather than emerging companies attempting to scale breakthrough technologies.

Of the CHIPS Act's manufacturing awards announced through 2024, no money went to companies building their first commercial-scale facility. Every recipient already operated semiconductor fabs at multi-billion dollar scale. The DOE Loan Programs Office (LPO) shows

29 Institute for Security and Technology, interviews with deep-tech venture capital investors and operators, 2025 (anonymized per interviewee requests).

30 U.S. Small Business Administration, "Small Business Innovation Research (SBIR) Program," SBIR.gov, accessed October 28, 2025, https://www.sbir.gov/.

31 U.S. Department of Energy, "ARPA-E Program Overview and Appropriations," FY2009–2023, https://arpa-e.energy.gov/.

32 U.S. Government Accountability Office (GAO), "DOE Loan Programs: Actions Needed to Address Authority and Improve Application Reviews," GAO-25-106631, May 8, 2025, https://www.gao.gov/products/gao-25-106631.

33 Intel Corporation, "Intel, Biden-Harris Administration Finalize $7.86 Billion Funding Award Under US CHIPS Act," Intel Newsroom, https://www.intel.com/content/www/us/en/newsroom/news/intel-biden-harris-administration-finalize-chips-act-award.html; American Institute of Physics, "Huge CHIPS Grants Awarded to TSMC, Samsung, and Micron," April 19, 2024, https://www.aip.org/fyi/2024/huge-chips-grants-awarded-tsmc-samsung-and-micron.

similar concentration: of active loans in the LPO portfolio as of 2024, the vast majority support established energy companies or proven technologies at scale, with limited support for first-of-a-kind commercial facilities from emerging companies.[34]

The DOE Loan Programs Office, while designed to support innovative energy projects including first-of-a-kind facilities, faces practical constraints in serving emerging companies. While LPO has supported some groundbreaking projects like first-of-a-kind facilities for established companies (e.g., Montana Renewables' $1.67 billion loan guarantee for sustainable aviation fuel expansion and Holtec's nuclear restart), emerging companies without operating history face higher barriers. A 2024 GAO report found that of the $108.3 billion in submitted applications across LPO's portfolio, the office processes applications at rates unlikely to deploy its full authorized capacity before statutory deadlines expire—suggesting institutional bandwidth constraints favor larger, more established applicants.[35]

The constraint is eligibility. DOE loans require companies to demonstrate "reasonable prospect of repayment," which in practice means proven financial models, established operations, and bankability that first-of-a-kind facility builders cannot demonstrate.[36] CHIPS Act funding prioritized strategic capacity expansion by manufacturers already operating at global scale. Companies seeking to build their first commercial facility lack the track record these late-stage programs demand.

This design reflects deliberate policy choices rather than accidental gaps. CHIPS Act drafters prioritized rapid, large-scale capacity addition to address geopolitical semiconductor supply vulnerabilities. The DOE Loan Programs Office operates under statutory requirements to protect taxpayer funds through conservative credit underwriting. Both represent rational program design for their specific objectives. The missing middle gap emerges not from program failure but from the absence of instruments designed specifically for first-of-a-kind commercial facilities that have validated technology but lack operating history.

The Gap Between Bookends

Consider a battery company's progression: it receives a $2 million SBIR Phase II grant to demonstrate its novel chemistry works, then raises $25 million in Series A venture capital to optimize cell design and demonstrate prototype manufacturing. With technical validation complete, it then needs $150 million to construct a pilot production line that will prove the technology can be manufactured at commercial scale and achieve target costs. The battery

34 U.S. Government Accountability Office, "DOE Loan Programs: Actions Needed to Address Authority and Improve Application Reviews."

35 U.S. Government Accountability Office, "DOE Loan Programs: Actions Needed to Address Authority and Improve Application Reviews."

36 Federal Register, "Loan Guarantees for Clean Energy Projects," 88 Fed. Reg. 34419, May 30, 2023, https://www.federalregister.gov/documents/2023/05/30/2023-11104/loan-guarantees-for-clean-energy-projects.

company is left with few options: ARPA-E grants have ended, SBIR provides no Phase III funding, and venture capital firms question whether $150 million for a pilot facility without revenue fits their fund economics. What's more, DOE loans require financial track records the company cannot provide, and CHIPS Act funds flowed to established semiconductor manufacturers. The missing middle gap becomes concrete: no existing federal instrument addresses this specific transition stage where breakthrough technologies must become scalable manufacturing.

The consequences are predictable: companies pivot to workarounds that distort optimal development pathways. Some pursue SPAC mergers to access public markets prematurely, as QuantumScape did—a route that largely collapsed by 2022 (though showing recent signs of revival). Others relocate manufacturing overseas where integrated state capital proves more accessible, transferring both production capabilities and intellectual property developed with U.S. taxpayer research funding. Still others simply fail—shuttering after exhausting Seed and Series A capital rounds, unable to bridge the gap to manufacturing scale despite validated technology. These failures create an additional vulnerability: bankruptcy courts can enable the acquisition and transfer of taxpayer-funded intellectual property to foreign competitors, including Chinese entities. Each outcome represents loss: of taxpayer research investment, of strategic manufacturing capability, of innovation advantages that should translate to American competitiveness, and potentially of the intellectual property itself through bankruptcy proceedings.

"We can work with clear rules and structured timelines even if restrictive. What we cannot work with is not knowing whether yesterday's commitment will still exist tomorrow. When policy commitments change week to week, companies cannot make multi-year investment decisions about facility construction, equipment procurement, and team building. Uncertainty kills momentum and wastes the capital companies already have."

Recent administrative changes introduced additional uncertainty beyond program design. Multiple investors we interviewed described companies receiving DOE loan commitments subsequently pulled back unexpectedly, or watching committed grant money face clawback attempts even after funds had been spent.[37] One investor explained: "We can work with clear rules and structured timelines even if restrictive. What we cannot work with is not knowing whether yesterday's commitment will still exist tomorrow. When policy commitments change

37 Maeve Allsup, "LPO on the chopping block again as DOE reviews $15 billion in awards," *Latitude Media*, May 21, 2025, https://www.latitudemedia.com/news/as-doe-reviews-15-billion-in-awards-lpo-may-again-be-on-the-chopping-block.

week to week, companies cannot make multi-year investment decisions about facility construction, equipment procurement, and team building. Uncertainty kills momentum and wastes the capital companies already have."[38]

Tax incentives demonstrate the timing mismatch problem. IRA Section 45X production credits can reduce manufacturing costs by approximately 30 percent once companies reach commercial scale–valuable support for operating facilities.[39] But companies only receive credits after they are already manufacturing commercially. Consider the case of the battery company: it needs $200 million to construct the factory that will eventually generate Section 45X credits, but cannot access those credits to help finance construction. The timing gap between when capital is needed (construction phase) and when credits materialize (production phase) limits effectiveness as a first-of-a-kind facility financing tool.[40]

When Federal Tools Work

The DOE loan guarantee portfolio from 2008 through 2010, including both Tesla's successful $465 million loan and Solyndra's high-profile failure, actually generated positive returns for taxpayers overall, losing only approximately 5 percent to failures while the rest performed well.[41] This success demonstrates that the government can effectively underwrite technical and market risk when programs target appropriate stages with proper credit analysis. The challenge is not government incapacity but rather program design misaligned with first-of-a-kind facility requirements.

Recent Industrial Policy Developments (2025)

Recent developments signal growing recognition of the missing middle gap. The Trump administration has taken equity stakes in critical minerals companies including MP Materials (where the Pentagon holds an approximately 15 percent stake to become the largest shareholder), Lithium Americas (where the where the Department of Energy holds a 5 percent equity stake in both the parent company and Thacker Pass joint venture, alongside a renegotiated $2.2 billion federal loan), and Trilogy Metals (where the Department of Defense holds a 10 percent stake, with a $35.6 million investment for Alaska mining projects).[42] The administration also converted a $10 billion federal grant to Intel into a 9.9 percent equity

38 Institute for Security and Technology, interviews with deep-tech venture capital investors and operators, 2025 (anonymized per interviewee requests)

39 Nicholas Buffie, "The Section 45X Advanced Manufacturing Production Credit," Congressional Research Service, IF12809, November 7, 2024, https://www.congress.gov/crs-product/IF12809.

40 Buffie, "The Section 45X Advanced Manufacturing Production Credit."

41 Jeff Brady, "After Solyndra Loss, U.S. Energy Loan Program Turning A Profit," *NPR,* November 13, 2014, https://www.npr.org/2014/11/13/363572151/after-solyndra-loss-u-s-energy-loan-program-turning-a-profit.

42 "Factbox-Trump Administration Pivots to Buying Stakes in Critical Sectors," *Reuters*, October 7, 2025, https://finance.yahoo.com/news/factbox-trump-administrations-investment-push-104654320.html.

stake to support domestic semiconductor manufacturing expansion. Revenue-sharing agreements with semiconductor companies Nvidia and AMD require 15 percent of their China sales revenue to flow to the U.S. government in exchange for export licenses.[43] The Stargate initiative, announced in January 2025, committed up to $500 billion over four years from OpenAI, Oracle, and SoftBank for AI infrastructure and data centers, with an initial $100 billion deployment.[44] These initiatives demonstrate awareness of manufacturing vulnerabilities and represent policy evolution toward incentivizing domestic production.

Beyond these executive actions, several federal financing mechanisms have emerged or expanded. The Office of Strategic Capital, established within the Department of Defense in December 2022 and formally authorized by the FY2024 National Defense Authorization Act, provides loans and loan guarantees with authority to deploy up to $984 million through FY2026 for dual-use technologies. Individual loans issued by the Office of Strategic Capital can range from $10 million to $150 million.[45] In addition, Defense Production Act Title III authorities provide direct investment for defense-critical production capacity. Congress appropriated at least $4.4 billion to the DPA Fund from FY2020 through FY2025.[46] The Development Finance Corporation operates with $60 billion in exposure capacity, having built its portfolio to nearly $50 billion including more than $12 billion in new commitments in FY2024.[47] Finally, the Export-Import Bank authorized $8.4 billion in transactions in FY2024.[48]

Yet measured against our framework, these tools largely operate outside the $50-300M first-of-a-kind facility transition stage. Equity stakes and the Office of Strategic Capital provide capital at venture scale ($10-150M per transaction) rather than first-of-a-kind facility scale. Revenue-sharing arrangements presume companies have already reached commercial production—the stage our analysis shows companies struggle to reach. Defense Production Act Title III targets defense supply chains specifically, while the Development Finance Corporation's geographic mandate prioritizes lower and lower-middle-income countries, explicitly excluding most domestic U.S. manufacturing. Meanwhile, the Export-Import Bank requires established production capability and export operations before financing becomes

43 Alan Wm. Wolff, "Trump's Nvidia-AMD deal adds to the legal questions about US trade policies," Peterson Institute for International Economics, August 28, 2025, https://www.piie.com/blogs/realtime-economics/2025/trumps-nvidia-amd-deal-adds-legal-questions-about-us-trade-policies.

44 Clare Duffy, "Trump announces a $500 billion AI infrastructure investment in the US," *CNN Business*, January 22, 2025, https://www.cnn.com/2025/01/21/tech/openai-oracle-softbank-trump-ai-investment.

45 Jon Harper, "DOD's Office of Strategic Capital accepting loan applications as it looks to lend up to $984M," *DefenseScoop*, January 3, 2025, https://defensescoop.com/2025/01/02/dod-office-of-strategic-capital-osc-loan-applications-credit-program-984m/.

46 Alexandra Neenan, "The Defense Production Act of 1950: History, Authorities, and Considerations for Congress," R43767, Congressional Research Service, https://www.congress.gov/crs-product/R43767.

47 DFC, "Five takeaways from DFC's first five years," Medium (blog), December 3, 2024, https://dfcgov.medium.com/five-takeaways-from-dfcs-first-five-years-7aeb7fc2888f.

48 "Export-Import Bank of the United States Marks 90th Anniversary with $8.4 Billion in FY24 Deals," press release, Export-Import Bank, November 12, 2024, https://www.exim.gov/news/export-import-bank-united-states-marks-90th-anniversary-84-billion-fy24-deals-supporting-38000.

accessible. While these mechanisms expand federal capacity, they operate at later stages requiring proven operations (like the Development Finance Corporation and Export-Import Bank) or target defense-specific manufacturing (such as Defense Production Act Title III and the Office of Strategic Capital), rather than the commercial first-of-a-kind transitions our research identifies as the critical competitive bottleneck where state-owned Chinese policy banks, which provide strategic lending aligned with Beijing's industrial priorities, systematically outpace American financing options.

The Strategic Vulnerability

The missing middle gap creates measurable strategic disadvantage. From 2020 through 2024, U.S. clean energy and deep-tech companies raised record Seed and Series A funding, yet struggled to convert technological leadership into manufacturing dominance.[49] Solar panel production shifted 80+ percent to China despite American innovation in photovoltaic technology, exemplifying the pattern where U.S. early-stage innovation leadership fails to translate into manufacturing dominance. In another example, electric vehicle (EV) production surged to a 60 percent global share in China, even as American companies pioneered EV technology.

The pattern is consistent: American research and early-stage funding generate breakthrough technologies through foundational R&D and early-stage prototyping; Chinese integrated capital deployment captures manufacturing scale. While American companies navigate fragmented financing between early grants, private investment, and late-stage loans, Chinese competitors can successfully access integrated capital. For example, the Chinese company Contemporary Amperex Technology (CATL), founded in 2011, reached global market leadership by 2017 and a 38 percent market share by 2024. This dominance was achieved through coordinated state capital deployment across research, pilot facilities, and commercial manufacturing.[50] The company received $790 million in state subsidies in 2023 alone, enabling continuous capacity expansion.[51] In part because of the success of CATL's lithium-ion battery dominance, Chinese companies now collectively control 76 percent of global lithium-ion battery production, not through superior technology but through integrated capital allocation that American firms cannot access through fragmented public-private financing pathways.

Understanding where China's integrated model succeeds and where it systematically fails provides competitive intelligence for designing American instruments that must outperform to

49 HolonIQ, "Defying gravity, 2022 Climate Tech VC funding totals $70.1B, up 89% on 2021," https://www.holoniq.com/notes/2022-climate-tech-vc-funding-totals-70-1b-up-89-from-37-0b-in-2021; Bianca Giacobone, "Raising Cleantech Venture Capital Funds Is Harder Than Ever," *Latitude Media*, March 26, 2025, https://www.latitudemedia.com/news/raising-cleantech-venture-capital-funds-is-harder-than-ever.

50 Vincent Sun, "Leading Battery Maker CATL Is Riding on the Electric Vehicle Tailwind," Morningstar, March 17, 2025, https://www.morningstar.com/company-reports/1270560.

51 Sun, "Leading Battery Maker CATL Is Riding on the Electric Vehicle Tailwind."

maintain strategic position. In the next section, we explore how Beijing's approach combines policy banks, government guidance funds, and direct subsidies into coordinated capital deployment—achieving manufacturing dominance in mature technologies, even as it suffers from political paralysis, capital misallocation, and innovation dysfunction. The question is whether targeted American partnership mechanisms can achieve superior integration, in effect matching China's patient capital and coordination advantages while preserving the innovation discovery and risk-taking that state direction suppresses.

Part II: Understanding China's Deep-Tech Investment Ecosystem

China has constructed the world's largest state capital apparatus for deep technology. It has raised $940 billion through 2,107 government guidance funds,[52] deployed $209 billion through policy banks from 2000-2023,[53] and launched the "Big Fund" in 2024, a $47.5 billion semiconductor fund—the largest ever.[54] Yet 66 percent of guidance funds have not made any investments,[55] the "Big Fund" was paralyzed for five months during the 2022 corruption investigations, and top-tier venture capitalists now actively avoid government capital despite its availability. This is not simply dysfunction—it's bifurcation. China's model is diverging into two parallel tracks: one delivering manufacturing dominance in mature technologies, the other creating selection crises in frontier innovation. Understanding where Beijing's approach generates genuine advantages and where it systematically fails constitutes competitive intelligence for American strategy.

Manufacturing Dominance: Where Integration Works

China's most effective deep-tech financing comes not from celebrated guidance funds but from policy banks—state lenders providing capital at scales, speeds, and costs private markets cannot match. The China Development Bank and Export-Import Bank of China deployed $209 billion through 367 loans from 2000-2023, financing infrastructure and strategic industries globally.[56]

52 Ngor Luong, Zachary Arnold, and Ben Murphy, "Understanding Chinese Government Guidance Funds: An Analysis of Chinese-Language Sources," Georgetown University Center for Security and Emerging Technology, March 2021, https://cset.georgetown.edu/publication/understanding-chinese-government-guidance-funds/.

53 Boston University Global Development Policy Center, "China's Global Energy Finance Database," Boston University Global Development Policy Center, accessed January 2025, https://www.bu.edu/gdp/chinas-global-energy-finance/.

54 Qin Min and Han Wei, "China Piles $47.5 Billion Into 'Big Fund III' to Boost Chip Development," *Caixin Global*, May 28, 2024, https://www.caixinglobal.com/2024-05-28/china-piles-475-billion-into-big-fund-iii-to-boost-chip-development-102200633.html.

55 Luong, Arnold, and Murphy, "Understanding Chinese Government Guidance Funds."

56 Boston University Global Development Policy Center, "China's Global Energy Finance Database."

These institutions move with remarkable speed when projects align with political priorities, though complex Belt and Road deals may require years of negotiation given geopolitical sensitivities.[57]

More importantly, policy banks provide structural cost-of-capital advantages that compound over hardware development timelines. OECD analysis found China's four state-backed semiconductor companies—including Semiconductor Manufacturing International Corporation (SMIC), the country's leading foundry—received $4.85 billion in below-market loans from 2014-2018, representing 98 percent of such financing among twenty-one studied companies globally.[58] Policy banks provided these loans at concessional rates and extended tenors unavailable through commercial channels. This structural advantage compounds over the fifteen-to-twenty-year horizons required for semiconductor manufacturing, creating differentials private capital cannot overcome through operational efficiency alone.

The battery sector crystallizes what this integration achieves. Contemporary Amperex Technology (CATL) commands 38 percent of global market share while maintaining commercial viability: in the first quarter of 2025, it delivered $11.8 billion in revenue and $2 billion in net profit with 24.4 percent gross margins.[59] Government support created conditions for success, including $47 billion in electric vehicle subsidies from 2009-2022,[60] a battery "white list" excluding foreign suppliers from 2015-2019,[61] coordinated infrastructure investment, and patient policy bank financing. The company received $790 million in state subsidies in 2023 alone, enabling continuous capacity expansion.

The results speak to manufacturing scale as deterministic rather than innovative. Chinese companies collectively control 76 percent of global lithium-ion battery production, 90 percent of cathode capacity, and 97 percent of anode manufacturing capacity[62]—commanding positions enabling economies of scale unavailable to American and Korean competitors. More capacity combined with lower cost of capital and protected ramp-up time enables predictable dominance in manufacturing-intensive domains.

57 Ammar A. Malik, Bradley Parks, Brooke Russell, Joyce Jiahui Lin, Katherine Walsh, Kyra Solomon, Sheng Zhang, Thai-Binh Elston, and Seth Goodman, "Banking on the Belt and Road: Insights from a new global dataset of 13,427 Chinese development projects," AidData, William & Mary, September 29, 2021, https://www.aiddata.org/publications/banking-on-the-belt-and-road.

58 Organisation for Economic Co-operation and Development, "Measuring Distortions in International Markets: Below-Market Finance," OECD Trade Policy Papers No. 247, 2021, https://doi.org/10.1787/a1a5aa8a-en.

59 Phate Zhang, "CATL Q1 2025 Earnings," *CnEVPost*, April 14, 2025, https://cnevpost.com/2025/04/14/catl-q1-2025-earnings/.

60 Varun Sivaram, Noah Gordon, and Daniel Helmeci, "Winning the Battery Race: How the United States Can Leapfrog China to Dominate Next-Generation Battery Technologies," Carnegie Endowment for International Peace, October 21, 2024, https://carnegieendowment.org/research/2024/10/.winning-the-battery-race-how-the-united-states-can-leapfrog-china-to-dominate-next-generation-battery-technologies?lang=en

61 International Energy Agency, "Global EV Outlook 2024: Trends in Electric Vehicle Batteries," International Energy Agency, April 23, 2024, https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-vehicle-batteries.

62 International Energy Agency, "Trends in Electric Vehicle Batteries."

Policy banks' effectiveness stems from institutional design implemented under Chen Yuan's Chinese Development Bank leadership from 1998 to 2013. Chen transformed the bank from a fiscal allocator into a commercially disciplined lender with internal risk assessment and multi-bureau approval systems that could reject politically favored but financially nonviable projects.[63] This created hybrid institutions combining state backing with professional credit evaluation. As a result, the bank offered below-market rates while maintaining remarkably low non-performing loan ratios. China's overall banking system maintained NPL ratios of around 1.5-1.6 percent through 2023, down from peaks above 12 percent in 2005, demonstrating improved financial discipline across the system.[64]

The trend on manufacturing scale: Getting stronger. Policy banks are becoming more sophisticated, companies are achieving genuine commercial viability while reducing subsidy dependence, and vertical integration delivers compounding advantages. Companies like CATL are achieving genuine commercial viability, and vertical integration delivers compounding advantages: controlling 76% of battery production, 90% of cathode capacity, and 97% of anode manufacturing creates economies of scale that competitors cannot overcome through technology alone. China has found a formula that works for established technology domains where success is capital-intensive and deterministic.

The Hefei Model: Professional State Capital

The municipal government of Hefei exemplifies what professional state investment can achieve with commercial discipline. In April 2020, strategic investors including Hefei City Construction invested 7 billion yuan ($990 million USD) for a 24.1 percent stake in the electric vehicle manufacturer NIO China, helping it overcome an acute liquidity crisis.[65] The deal demonstrated sophistication: NIO relocated its China headquarters to Hefei but retained 75.9 percent controlling equity and operational autonomy. The investment agreement included performance milestones; NIO China needed to file for IPO within forty-eight months or strategic investors could require share repurchase at 8.5 percent annual interest. Within two years, Hefei achieved approximately 5.5 times return as NIO's share price surged.[66] Rather than asserting control, Hefei reduced

63 Henry Sanderson and Michael Forsythe, *China's Superbank: Debt, Oil and Influence—How China Development Bank is Rewriting the Rules of Finance* (Hoboken, NJ: Bloomberg Press, 2013).

64 "China Non Performing Loans Ratio, 2005–2025," CEIC Data, accessed January 2025, https://www.ceicdata.com/en/indicator/china/non-performing-loans-ratio.

65 Jill Shen, "Nio Clinches RMB 7 Billion Cash Injection from Hefei Government," *TechNode*, April 29, 2020, https://technode.com/2020/04/29/nio-clinches-rmb-7-billion-cash-injection-from-hefei-government/.

66 Tom Hancock, "Where Is China Investing? Communist Leaders Are Becoming Venture Capitalists," *Bloomberg*, February 6, 2022, https://www.bloomberg.com/news/features/2022-02-06/where-is-china-investing-communist-leaders-are-becoming-venture-capitalists.

its position as the company turned profitable in 2021. By September 2024, strategic investors demonstrated continued confidence with an additional 3.3 billion yuan ($470 million) investment.[67]

The model succeeded because it balanced state capital deployment with company autonomy, included commercial discipline through exit mechanisms, and maintained professional management focused on returns rather than political objectives. Yet Hefei's success reveals a scaling problem: this approach requires sophisticated municipal governments, desperate unicorn companies, and the added urgency of a liquidity crisis to align incentives. Realistically, Hefei can execute perhaps ten such deals annually. To effectively compete, China would need thousands of Hefeis.

Strategic Priorities Over Capital Efficiency

An essential question emerges from China's financing dysfunction: Does Beijing view the 66 percent inactive guidance fund capital or the five months of "Big Fund" paralysis as failures? The evidence suggests that they do not, at least not when strategic manufacturing goals are met. A 2024 analysis found that 86 percent of the 260+ "Made in China 2025"[68] goals set by the Chinese government to transform China into a global innovation leader have been achieved, with targets in electric vehicles and renewable energy well surpassed.[69] China achieved global leadership in five critical technologies—high-speed rail, graphene, unmanned aerial vehicles, solar panels, and electric vehicles with lithium batteries—while closing the gap in seven others.[70] By 2023, China produced over 60 percent of global electric vehicles and controlled more than 50 percent of worldwide shipbuilding orders by tonnage. China's manufacturing value-add in 2023 reached 29 percent of the global total, almost the same output as the United States and European Union combined.[71]

Made in China 2025 represents the first phase of a plan extending to 2049. The plan identified ten priority sectors reflecting political imperatives beyond economics: semiconductors and aerospace for military-civil fusion, electric vehicles for both technological leadership and environmental goals, and advanced equipment for Belt and Road infrastructure projection. In a speech, Xi Jinping positioned these industries as fundamental to "national rejuvenation." He set

67 Phate Zhang, "Nio Announces $470 Million Investment in Nio China from Strategic Investors," *CnEVPost*, September 29, 2024, https://cnevpost.com/2024/09/29/nio-rmb-3-billion-investment-nio-china-investors/.

68 Kaiser Kuo, "Made in China 2.0: The Future of Global Manufacturing?," World Economic Forum, June 26, 2025, https://www.weforum.org/stories/2025/06/how-china-is-reinventing-the-future-of-global-manufacturing/.

69 Silva Shih and Yixuan Lin, "Made in China 2025: How China Thrives Despite Tech Sanctions," *CommonWealth Magazine*, vol. 809, October 15, 2024, https://english.cw.com.tw/article/article.action?id=3789.

70 Cheung Kong Graduate School of Business (CKGSB) Knowledge, "Made in China 2025: Looking at a Decade of China's Self-Sufficiency Drive," CKGSB Knowledge, June 26, 2025, https://english.ckgsb.edu.cn/knowledge/article/china-self-sufficiency-drive-made-in-china/.

71 Matteo Meloni, "'Made in China 2025': A Decade of Industrial Policy," *Special Eurasia*, May 12, 2025, https://www.specialeurasia.com/2025/05/02/made-in-china-2025/.

out the milestones of achieving manufacturing supremacy by 2035 and technological system dominance by 2049 as indicators for comprehensive national power.[72] For China, the ultimate goal is to ensure that it cannot be constrained by foreign technology dependencies, which comes second to capital efficiency. This is particularly evident in the case of semiconductor export controls and sanctions, when China accelerated domestic investment despite massive inefficiencies rather than accept continued dependence on Western technology.

Ultimately, strategic self-sufficiency, not capital efficiency, is China's optimization function. Beijing tolerates massive waste, political paralysis, and idle capital because manufacturing dominance in priority sectors outweighs these costs. Policy banks concentrate 98 percent of concessional financing in four semiconductor companies, guidance funds remain inactive for years, and corruption investigations freeze deployment for months. These are system features, not bugs, so long as strategic objectives advance. This creates asymmetric competition: China accepts inefficiency costs that democratic systems cannot politically sustain. In the case of the United States, American taxpayers and legislators would not tolerate $940 billion spent in government funds, of which only one-third is being used to actively invest while the rest sits idle in government coffers.

Yet this constraint becomes an advantage if converted into discipline. American mechanisms must achieve superior capital efficiency precisely because democratic accountability demands it. The strategic question is whether targeted public-private partnership can deliver coordination without centralization, leverage without waste, and strategic outcomes without the systematic dysfunction that plagues Chinese guidance funds. Success requires proving that partnership outperforms control, making American mechanisms not optional alternatives but competitive necessities.

The Innovation Paradox: Where Integration Stalls

True innovation requires risk-taking; political oversight mandates risk aversion. This structural incompatibility reveals itself most dramatically in China's guidance fund system. By 2022, Chinese officials had established 2,107 government guidance funds targeting $1.86 trillion in total capital, yet actual funds raised reached only $940 billion—barely half of the stated objectives. More troubling, Georgetown University's Center for Security and Emerging Technology found that only 34 percent of these funds completed even a single investment.[73] In Shenzhen alone, the city recovered 5.72 billion yuan (approximately $830 million) from nineteen inactive sub-funds in 2021.[74]

72 Nistha Kumari Singh and Amrita Jash, "Made in China 2025: From Assembly Lines to Innovation Frontiers," Institute for Security and Development Policy, October 8, 2025, https://www.isdp.eu/made-in-china-2025-from-assembly-lines-to-innovation-frontiers/.

73 Luong, Arnold, and Murphy, "Understanding Chinese Government Guidance Funds."

74 Wei, Ang, and Jia, "The Promise and Pitfalls of Government Guidance Funds in China."

To understand what $940 billion represents, consider that Chinese venture capital invested approximately $69.5 billion across 6,186 deals in 2022.[75] Government guidance funds raised represent roughly 37 percent of total Chinese venture capital assets under management (estimated at $2.5 trillion in 2022), yet account for less than 5 percent of actual deployments by deal count. This is capital abundance coupled with deployment poverty—a selection crisis where massive availability coincides with systematic non-use.

Further compounding the inefficiencies, geographic mandates misallocate capital to regions lacking innovation ecosystems. For example, the Guizhou Big Data Industry Fund targeted 100-150 billion yuan ($14-22 billion), but made zero investments by 2021 despite massive infrastructure construction.[76] As one private equity executive explained to us, “Within the province, there are not enough businesses in need of big data services, leading to a lack of new ventures offering such services for guidance fund investment.”[77] Capital cannot conjure ecosystems; hardware innovation clusters in specific locations with universities, talent pools, and industrial networks requiring decades to develop.

Governance structures guarantee risk aversion. A 2016 National Audit Bureau investigation found private capital accounted for only 15 percent of total capital in 235 sampled funds across sixteen provinces in China. In surveyed funds, 31 percent had government fiscal departments as observers, 29 percent required them as final approvers, and 25 percent included them on investment committees. Evaluation criteria assign a weight of 50% to “conservation of state assets,” valuing it even over financial returns.[78] Under Xi Jinping’s anti-corruption campaign, officials fear accusations of “state-asset loss” more than missing breakthrough innovations. As a result, surveyed guidance funds invested only 6.41 percent at the Seed stage and 18.69 percent in startups, concentrating instead on later stages that reduce political risk but fail to support genuine innovation.[79]

These failures create compounding dysfunction. When guidance funds remain inactive, it delegitimizes the model for both investors and entrepreneurs, making future fundraising harder. One managing partner of a firm controlling over 50 billion yuan ($7 billion) characterized government Seed funds as “insignificant” compared to independently raised capital, revealing that top investment talent actively avoids the system despite massive capital availability. This creates a death spiral: government funds attract second-tier managers unable to raise private capital, who then struggle to identify quality deals, reinforcing the pattern of non-deployment.

75 Kia Kokalitcheva,”Venture investing in China nearly cut in half in 2022,” *Axios*, April 1, 2023, https://www.axios.com/2023/04/01/china-venture-investing-rough-2022.

76 Wei, Ang, and Jia, “The Promise and Pitfalls of Government Guidance Funds in China.”

77 Institute for Security and Technology, interviews with deep-tech venture capital investors and operators, 2025 (anonymized per interviewee requests)

78 Wei, Ang, and Jia, “The Promise and Pitfalls of Government Guidance Funds in China.”

79 Wei, Ang, and Jia, “The Promise and Pitfalls of Government Guidance Funds in China.”

This "death spiral" is both due to China-specific political risk and more general problems with government capital. In particular, anti-corruption campaigns attempting to identify state-asset loss can halt deployment for months. As a result, China faces what we term "Big Fund paralysis:"

- Evaluation criteria emphasize asset preservation (with a 50 percent weight) over returns
- Officials rotate faster (3-5 years) than venture returns can materialize (7-10 years)
- Geographic mandates override deal quality (e.g., Guizhou set a $100-150 billion target, but has zero investments)
- Political risk aversion prevents the aggressive deal-making essential for breakthrough technology

Taken together, this "Big Fund paralysis" means that frontier innovation is only getting worse. The 2022-23 corruption probe did not just pause the Big Fund—it created lasting risk aversion across the system. Top-tier firms with 50+ billion yuan now call government funds "insignificant." Capital is becoming more abundant, even as talent flight accelerates.

Big Fund Paralysis: When Political Risk Compounds Financial Risk

The National Integrated Circuit Industry Investment Fund (Big Fund) illustrates Chinese state capital's vulnerability to political dynamics. Phase I, established in 2014 with approximately $20 billion, invested across China's semiconductor value chain. Over 67 percent of Phase I went towards supporting contract manufacturers, including SMIC.[80] Phase II launched in 2019 with $29 billion to continue this trajectory. Then political risk struck.

In July 2022, China's Central Commission for Discipline Inspection announced an investigation of Lu Jun, former chief executive of Sino IC Capital, the sole management entity for the Big Fund. They accused him of "suspected serious violations of discipline and law."[81] At the time, Sino IC Capital held approximately $17-18 billion (120 billion yuan) in assets under management. The investigation rapidly expanded: by September 2022, Ding Wenwu, the Big Fund's president since inception, as well as at least five additional executives faced investigation.[82]

The investigations paralyzed deployment of the fund. From late March through August 2022, the Big Fund made zero investments. Total investments dropped to eight in 2022, down

80 Wei Sheng, "Where China Is Investing in Semiconductors, in Charts," TechNode, March 4, 2021, https://technode.com/2021/03/04/where-china-is-investing-in-semiconductors-in-charts/.

81 Jiaxing Li, "Another Heavyweight Involved in China's Chip Independence Drive Comes Under Official Investigation," *South China Morning Post*, July 29, 2022, https://www.scmp.com/tech/policy/article/3187085/another-heavyweight-involved-chinas-chip-independence-drive-comes-under.

82 Li Jiaxing, "China's State-Run Semiconductor Fund Engulfed in Scandal as Beijing Probes Three Senior Executives for Alleged Corruption," *South China Morning Post*, August 2, 2022, https://www.scmp.com/tech/tech-war/article/3187336/chinas-state-run-semiconductor-fund-engulfed-scandal-beijing-probes.

from fourteen in 2021.[83] Despite holding $29 billion in Phase II capital, the fund effectively sat dormant for five months.

In early 2023, the fund eventually resumed operations. By May 2024, it launched Phase III with $47.5 billion in registered capital—larger than Phases I and II combined.[84] Yet the corruption investigations demonstrated that capital availability means little if governance concerns paralyze deployment. When massive sums flow through limited institutional channels and officials fear accusations of state-asset loss more than missing strategic opportunities, the risk-taking essential for technology investment becomes politically untenable.

The Bifurcation: Two Systems, Diverging Trajectories

Figure 3: The Bifurcation: Two Systems, Diverging Trajectories

China's deep-tech financing is splitting into two fundamentally incompatible models:

PROFESSIONAL STATE CAPITAL (HEFEI MODEL)

Commercial discipline
Fund operates with performance milestones, penalty clauses, and exit discipline

Autonomy preservation
Founders retain control and operational independence

Returns-focused
Hefei achieved 5.5x return in two years, sold when companies turn profitable

Scaling limit
The Hefei model requires rare alignment of municipal competence, company desperation, and crisis urgency. While Hefei can execute perhaps 10 deals per year, China needs 1,000+ nationwide.

POLITICAL CAPITAL (GUIDANCE FUND MODEL)

Inactive funds:
Of **2,107 funds** and **$940 billion** raised, **66 percent** remained inactive

Selection death spiral
Government funds attract second-tier managers who make poor selections, reinforcing non-deployment

Geographic mandates trump quality
Guizhou targets $100-150 billion, but achieves zero investments, demonstrating that capital cannot conjure ecosystems.

The crisis
Top-tier venture capital firms avoid government funds despite capital abundance

83 Eduardo Jaramillo, "After a Year of Corruption Scandals, China's National Chip Fund Forges Ahead," The China Project, January 4, 2023, https://thechinaproject.com/2023/01/04/after-a-year-of-corruption-scandals-chinas-national-chip-fund-forges-ahead/.

84 Qin Min and Han Wei, "China Piles $47.5 Billion Into 'Big Fund III' to Boost Chip Development," *Caixin Global*, May 28, 2024, https://www.caixinglobal.com/2024-05-28/china-piles-475-billion-into-big-fund-iii-to-boost-chip-development-102200633.html.

This bifurcation matters because China cannot scale Hefei, while America might be able to. The question is whether any system can occupy the "fast deployment + good judgment" quadrant that currently remains empty.

Cross-Border Fracture and Institutional Opacity

United States-China tensions fractured cross-border venture capital flows between June 2023 and July 2024. Every major China-focused venture firm with American ties executed formal separations: for example, HongShan (formerly Sequoia China) split in June 2023 with $56 billion under management, while Matrix Partners China rebranded as MPC in July 2024.[85] The result was a domestic venture landscape establishing new operating rhythms independent of Western capital networks.

Military-Civil Fusion—a concept that prioritizes eliminating barriers between civilian and military uses—was elevated to a Chinese national priority in 2017.[86] The system operates through institutional channels that in turn preserve plausible deniability. Venture investors embedded in Military-Civil Fusion networks retain board seats in strategic technology companies, creating channels for technology transfer without transparent military representation. For hardware deep-tech sectors like semiconductors, advanced materials, and precision manufacturing equipment that possess both civilian and military applications, these mechanisms matter enormously.

Yet despite institutional integration at the higher, more strategic levels, China's top-tier venture capital firms actively avoid government guidance funds at operational levels. Private venture capitalists are embedded in state coordination mechanisms for strategic sectors, yet reject direct co-investment with government funds, whether because of geographic mandates, sectoral restrictions, or political risk. This reveals fundamental incompatibility between state direction and judgment-intensive technology investing.

The American Asymmetry

China has solved specific parts of the deep-tech financing challenge. Policy banks effectively deploy patient capital for manufacturing scale-up in mature technologies, as CATL and SMIC demonstrate. The broader system's dysfunction—including the vast amounts of inactive capital in guidance funds and the perception that government funds are 'insignificant' despite

85 U.S. House Select Committee on the Strategic Competition Between the United States and the Chinese Communist Party, "The CCP's Investors: How American Venture Capital Fuels the PRC Military and Human Rights Abuses," February 2024, https://selectcommitteeontheccp.house.gov/sites/evo-subsites/selectcommitteeontheccp.house.gov/files/evo-media-document/2024-02-08%20-%20VC%20Report%20-%20FINAL.pdf.

86 U.S. House Select Committee on the Strategic Competition Between the United States and the Chinese Communist Party, "The CCP's Investors: How American Venture Capital Fuels the PRC Military and Human Rights Abuses."

availability—tells a more complex story. This dysfunction may manifest differently across sectors, with investor flight potentially more pronounced in software and AI than in capital-intensive hardware. Yet even in hardware domains, the system fails at first-of-a-kind facilities requiring technical validation plus massive capital, innovation selection demanding judgment, and risk-taking that political oversight suppresses.

This creates asymmetric opportunities for American strategy. China's integration through state direction delivers coordination and scale in specific contexts but generates systematic failures elsewhere. Political paralysis, capital misallocation, and selection crises worsen as technologies move from mature manufacturing toward frontier innovation.

What America cannot replicate:

» **Three-month policy bank approvals:** China achieves rapid financing decisions because policy banks are wholly state-owned entities operating under unified political direction, enabling coordination that America's fragmented private banking system and independent regulatory oversight cannot match.

» **Indefinite patient capital at below-market rates:** China's state banks can provide 15-year loans at 1-2% interest rates because they operate outside market discipline and answer to political directives rather than shareholders, while American lenders face democratic budget cycles, congressional appropriations constraints, and capital market accountability that prevent sustained below-market lending.

» **Protected domestic ramp-up markets:** China can explicitly exclude foreign competitors during critical scaling periods through industrial policies and procurement preferences, while America's WTO commitments, trade agreements, and open market principles legally constrain the use of protectionist measures to shield emerging domestic manufacturers.

What America might do better:

» **Combine judgment with scale, avoiding China's bifurcation:** China's system splits into professional state capital (Hefei) that cannot scale and political capital (guidance funds) that attracts second-tier talent; American public-private partnerships could preserve top-tier venture capital judgment while adding patient capital at scale, achieving what China's parallel systems cannot.

» **Cultivate transparent governance that attracts global capital:** China's Military-Civil Fusion integration and opaque state control actively repel Western institutional investors, driving complete separation of major venture firms by 2024; American programs with clear public-private boundaries and commercial discipline could set the global standard for strategic investment that mobilizes rather than frightens international capital.

» **Enable institutional learning across failures:** China knows Guizhou's $100-150 billion fund failed but cannot systematically study or publicize the lessons without admitting policy mistakes; American ARPA models have fifty years of documented iteration, published failure analysis, and adaptive program design that turns setbacks into institutional knowledge rather than political liabilities.

Can America build instruments delivering fast deployment with good judgment? China is trying and failing—the Big Fund achieved scale but not speed, guidance funds achieved neither, and only Hefei achieved both but cannot scale. The convergence of speed and selection quality remains an unsolved problem in government technology investment. Solving it would constitute genuine competitive advantage rather than mere replication of China's manufacturing-focused approach.

This requires instruments designed specifically for the missing middle: partnering with venture capital at the scale-up stage, delivering coordination without control, providing patient capital without political paralysis, and maintaining the commercial discipline that prevents the selection death spiral currently consuming China's guidance fund system. The question is not whether America can match China's $940 billion in government funds, but whether it can deploy capital more effectively at one-tenth the scale.

Part III: Winning the Missing Middle: Four Mechanisms to Outcompete China

The Race America Must Win

> "I've watched Chinese competitors building their first factories with state bank financing while our portfolio companies are on their 150th investor pitch. The Chinese company reaches commercial production eighteen to twenty-four months faster, establishes the price point, and captures the market before our technology ever scales."[87]

This investor that we spoke to in our interviews operates in both ecosystems. They see the competitive reality daily: China's policy banks deploy $200+ billion at 1.2 percent interest with three-month approvals. American companies wait twelve to twenty-four months for uncertain federal commitments at commercial rates. When speed determines who establishes the price point and captures market share in manufacturing-intensive technologies, systematic disadvantage compounds into strategic loss.

Yet the comparison reveals asymmetric American advantages. Venture capital generates breakthrough technologies that state direction cannot replicate: the United States

87 Institute for Security and Technology, interviews with deep-tech venture capital investors and operators, 2025 (anonymized per interviewee requests).

maintains clear leadership in artificial intelligence, advanced software, quantum computing fundamentals, and biotechnology despite China's manufacturing dominance. Transparent governance attracts the global capital that China's opacity repels. The strategic opportunity is solving the missing middle gap through targeted partnership. American innovation discovery combined with manufacturing scale-up capability can outcompete Chinese follow-fast manufacturing across the full commercialization pipeline.

As Michael Brown and Pavneet Singh framed it in their report on the link between venture capital and industrial strategy, the central question is "How do we adapt our system to compete without destroying what makes it effective in the first place?"[88] The answer: draw specific mechanisms from China's approach while deliberately rejecting others. China achieves coordination through state control but suffers political paralysis, capital misallocation, and innovation dysfunction. The United States can achieve superior integration through partnership—combining venture capital's innovation strengths with public capital's scale and patience, without sacrificing dynamism.

Four Mechanisms to Close the Gap

Comparative analysis reveals four specific mechanisms where targeted public intervention unlocks private capital at the missing middle stage. Each mechanism addresses a documented gap where American companies lose to Chinese competitors, not through inferior technology but through systematic financing disadvantage.

1. Patient Capital at First-of-a-Kind Scale

- **The Gap:** China provides fifteen-year loans at 1.2 percent interest for first-of-a-kind facilities, creating 2 to 4 percentage point cost advantages that compound over manufacturing timelines.[89] American companies access commercial debt at 4 to 6 percent over 5 to 7 year terms—if they can access project finance at all before demonstrating commercial production. This systematic disadvantage determines competitive outcomes in capital-intensive hardware.

> **"We don't need the government to pick winners. We need the government to make it possible for us to finance the winner once we've identified it. A loan guarantee enables us to act at a scale we otherwise couldn't."**

- **The Solution:** Loan guarantees enabling private lending at patient terms without state ownership. As demonstrated in Part I, private equity firms and project finance banks possess the capital and routinely finance $50 to $200 million infrastructure investments—loan guarantees

88 Michael Brown and Pavneet Singh, "Why Venture Capital is Indispensable for U.S. Industrial Strategy," Institute for Security and Technology, October 2024, https://securityandtechnology.org/wp-content/uploads/2024/10/Why-VC-is-Indispensable-for-U.S.-Industrial-Strategy.pdf.

89 Boston University Global Development Policy Center, "China's Global Energy Finance Database," accessed January 2025.

make first-of-a-kind facilities financeable using existing private equity and project finance capacity. One deep-tech investor explained the distinction: “We don’t need the government to pick winners. We need the government to make it possible for us to finance the winner once we’ve identified it. A loan guarantee enables us to act at a scale we otherwise couldn’t.”

» **The Mechanism:** $50 to $100 billion loan guarantee facility specifically for first-of-a-kind manufacturing, enabling fifteen-year commercial debt at sub-3 percent rates when combined with private equity investment. Loan guarantees generate 5 to 10 times leverage—every $1 of federal guarantee catalyzes $5 to $10 in private project finance.[90] This preserves what works: venture capital identifies promising technologies and leads equity investment, while public guarantees address the specific gap that venture capital cannot fill: long-tenor, patient debt for unproven manufacturing facilities.

2. Speed and Commitment Credibility

» **The Gap:** China’s three-month policy bank approvals versus American twelve-to-twenty-four month timelines create competitive timing advantage.[91] More damaging than the delay is the recent instability—the withdrawal of DOE loans and grants clawed back mid-project creates uncertainty worse than capital absence. Multiple operators emphasized in interviews that they e can plan around twelve-month timelines if reliable, but they cannot plan when yesterday’s commitment might not exist tomorrow.

» **The Solution:** Statutory speed requirements and commitment protection that creates planning certainty without requiring Chinese-style state bank ownership.

» **The Mechanism:**

- » Six-month statutory approval deadlines for federal programs with independent review if exceeded
- » Commitments protected from reversal once made, with statutory limitations on clawback authority
- » Independent program management insulated from political appointee interference
- » Penalties for agencies missing deadlines that create real accountability

3. Demand-Side Coordination: Contracts as Capital Magnets

» **The Gap:** Chinese companies secure guaranteed government demand through state coordination. American deep-tech companies face revenue uncertainty, even when developing breakthrough technologies. The U.S. Defense Department awarded 99 percent of $406 billion in contracts to incumbent defense companies in 2023, with only 1 percent to new, venture-backed companies.[92]

» **The Solution:** Advanced purchase commitments and procurement contracts that remove revenue risk without government picking technology winners. IST’s earlier analysis found Defense

90 Estimated based on DOE Loan Programs Office historical transaction leverage ratios.

91 Ammar Malik, Bradley Parks, et al., “Banking on the Belt and Road,” AidData at William & Mary, 2021, https://www.aiddata.org/publications/banking-on-the-belt-and-road.

92 Defense Innovation Unit, “Annual Report FY2022,” January 2023, https://www.diu.mil/resources/annual-report/annual-report-fy22.pdf.

Innovation Unit prototype contracts generated 10 to 20 times the leverage: every $1 of contract value attracted $10 to $20 in additional private equity investment. This validates the broader principle: the right public signal at the right stage unlocks substantially larger private capital flows.

Procurement commitments are the most powerful action available. They address the exact revenue certainty gap that prevents project finance banks from underwriting first-of-a-kind facilities. One venture managing partner invested primarily in software shared in interviews: "I would be equally interested in hardware investments if the government demonstrated its interest with contracts and orders." No other mechanism—not tax credits, not direct grants, not equity co-investment—matches the power of credible demand signals.

» **The Mechanism:** $20 to $30 billion in advanced market commitments across the Defense Department, Department of Energy, and General Services Administration for strategic technologies meeting performance specifications. The mechanism would be technology-agnostic on implementation: the government defines outcomes (e.g., secure communications, persistent surveillance, or distributed energy storage), while companies compete on approaches. Contracts would be awarded early to prove demand and scaled as companies demonstrate delivery.

4. Technology Maturity Demonstration: Small Grants, Massive Leverage

» **The Gap:** Venture capital structurally avoids early-stage hardware requiring expensive demonstrations before proving commercial viability. Federal SBIR programs provide modest grants but historically achieve only 1 percent transition to production.[93] The missing piece: targeted non-dilutive capital specifically demonstrating technology readiness at inflection points.

» **The Solution:** Small public investments proving technology maturity would enable substantially larger private capital raises. The National Security Innovation Capital program, despite its modest $15 million annual appropriation, demonstrates the model: targeted grants enable companies to raise Series A venture financing previously unavailable.[94] Anthro Energy, a company that produces polymer batteries, had zero venture investors before NSIC support; the grant enabled successful Series A financing. Maybell Quantum, which specializes in dilution refrigerators, raised $25 million Series A after NSIC-supported demonstrations.[95]

» **The Mechanism:** $500 million to $1 billion annual program for non-dilutive grants, awarded in the $10 to $50 million range, to help demonstrate technology readiness at critical milestones. Grants fund specific demonstrations that reduce uncertainty for follow-on private investors, such as manufacturing pilot lines, system integration testing, performance validation at scale, customer trials demonstrating product-market fit.

93 Mary Gallo, "Small Business Research Programs: SBIR and STTR," Congressional Research Service, October 21, 2022.

94 Alexandra Lohr, "National Security Innovation Capital meets investment milestone for the year," *Federal News Network*, July 10, 2023, https://federalnewsnetwork.com/defense-main/2023/07/national-security-innovation-capital-meets-investment-milestone-for-the-year/

95 Brown and Singh, "Why Venture Capital is Indispensable for U.S. Industrial Strategy."

Design Principles: Partnership Without Control

These mechanisms succeed only if designed to preserve American innovation advantages rather than replicate Chinese dysfunction. Five principles ensure effective implementation:

Venture Capital Identifies; Public Capital Enables

Let venture capital find promising technologies. Public capital addresses specific gaps that venture capital cannot fill, not technology selection. China's guidance funds attract second-tier managers because top-tier venture capitalists avoid government capital despite massive availability. American mechanisms must be instruments that top-tier investors want to deploy, not parallel systems they circumvent.

Merit Over Geography

Capital follows capability, not political boundaries. Chinese geographic mandates created the Guizhou failure: $100 to $150 billion targeted, yet zero investments deployed because of a lack of businesses within the province. American mechanisms must enable concentration in innovation hubs—like Silicon Valley, Boston, Austin, and Seattle—because clustering is a competitive advantage, not market failure.

Transparent Governance Attracts Global Capital

Maintain a clear separation between public support and private investment to attract capital that Chinese opacity repels. Every Western venture firm separated from Chinese operations in 2023-2024 because Military-Civil Fusion integration creates unacceptable governance risk. American mechanisms succeed by establishing clear boundaries: public capital provides specific enablers, like guarantees, contracts, and grants, while private investors maintain governance control and strategic direction.

Risk Tolerance Over Asset Preservation

Implement independent management, clear criteria, and risk-tolerant evaluation measuring strategic outcomes rather than asset preservation. Chinese officials fear state-asset loss accusations more than missing breakthrough innovations—evaluation criteria emphasize asset conservation at 50 percent weight. American mechanisms must reward calculated risk-taking: some investments will fail, but program success must measure private capital mobilized and strategic capabilities developed, not zero-loss preservation of public funds.

Measure Leverage, Not Deployment

Evaluate programs on private capital mobilized per public dollar, not direct government spending. Chinese guidance funds raised $940 billion, yet 66 percent made zero investments—marking capital abundance with deployment poverty. American success looks different: $50 billion in loan guarantees catalyzing $500 billion in private project finance, $1 billion in maturity grants enabling $10 billion in follow-on venture investment, and $30 billion in procurement contracts attracting $300 billion in manufacturing scale-up. Taken together, this means that public capital is measured by private capital unlocked, not public capital deployed.

The Path Forward

These four mechanisms form an integrated framework for closing America's missing middle gap without replicating Chinese dysfunction. Implementation requires no fundamental restructuring—these are targeted interventions using existing authorities, like loan guarantees, procurement contracts, non-dilutive grants, and statutory timelines. These targeted interventions must be deployed with strategic focus to target areas where American companies systematically lose despite technological superiority. The leverage mathematics are compelling: $50 billion in loan guarantees could catalyze $500 billion in private manufacturing investment, $30 billion in procurement commitments could attract $300 billion in venture capital and project finance, $1 billion in maturity grants could unlock $10 billion in follow-on investment. The result? Public capital measured by private capital mobilized, not public capital deployed.

Success looks fundamentally different from the outcomes of Chinese state direction. Rather than $940 billion in government funds making zero investments, or political paralysis consuming deployment time, or top-tier investors actively avoiding government capital, venture capital leads technology selection and maintains governance control, public capital provides specific enablers that unlock private investment, transparent rules replace discretionary approval, and risk tolerance rewards breakthrough capabilities. This requires discipline. resisting pressure to pick winners, protecting commitment credibility from political interference, maintaining merit-based allocation over geographic distribution, measuring success by leverage ratios rather than direct deployment.

America has an opportunity to demonstrate that partnership outperforms control. China has shown the missing middle can be crossed through state capital. America must prove it can be crossed better. Four mechanisms provide the answer. Implementation determines the outcome.

Conclusion: The Decisive Decade

China's manufacturing-focused model wins when technologies are known and success is execution-dependent: batteries, solar panels, mature semiconductor nodes. The American innovation-focused model wins when technologies are novel and success requires breakthrough discovery: generative AI, biotechnology, advanced software. AI infrastructure and data centers demonstrate that when demand certainty, proven technology, and revenue visibility align, American capital flows abundantly—private equity deployed $50 billion to data centers in 2024 alone. The missing middle exists where these conditions are absent, but strategic necessity demands action.

Without these four mechanisms, American companies generate breakthrough technologies then lose manufacturing scale-up to Chinese competitors who have patient capital and guaranteed demand. Chinese companies establish price points, capture market share, and generate economies of scale that American innovators cannot overcome through superior technology alone. This pattern repeats across lithium-ion batteries and electric vehicles, and increasingly threatens quantum computing, advanced materials, and next-generation telecommunications.

With these mechanisms, American companies maintain innovation leadership while capturing manufacturing scale-up. Venture capital continues to identify and fund breakthrough technologies, with no incentive required for software and AI development. Public-private partnership addresses the specific gap where American companies systematically lose: the missing middle transition from demonstrated technology to manufacturing scale, where Chinese policy banks provide three-month approvals at 1.2 percent interest while American companies struggle to assemble patient capital despite proven capabilities.

The strategic question is not whether America can match China's $940 billion in government funds or replicate three-month policy bank approvals. Rather, the question is whether America can achieve superior outcomes through partnership mechanisms that preserve innovation advantages while matching China's patient capital and speed. Solving this challenge determines technology leadership in the decisive decade of strategic competition.

China shows the missing middle can be crossed via state capital. America must demonstrate it can be crossed better through targeted partnership, by combining venture capital's innovation discovery with public capital's scale and patience and avoiding the political paralysis, geographic misallocation, and selection crises that consume $940 billion in Chinese capital and produce 66 percent failure rates. The goal is not to match China's capital deployment but achieve superior outcomes: unlocking the $1.3 trillion in private equity and project finance capital that already exists by making first-of-a-kind facilities financeable through partnership mechanisms. Superior integration through partnership, not control. Competitive advantage China cannot replicate.

Appendix A: Top U.S. Deep-Tech Venture Investors (2020–2025)

Scope & method: This chart captures U.S.-headquartered venture investors with explicit deep-tech theses and/or dedicated deep-tech vehicles. Each is reported with the latest publicly stated assets under management (AUM) or deep-tech vehicle size (as-of 2020–2025). For each, we note focus, stage, and representative U.S. portfolio examples.

Firm / deep-tech vehicle	AUM / vehicle size (as-of)	Deep-tech focus highlights	Typical stage	Representative U.S. portfolio (indicative)
Andreessen Horowitz (a16z) — American Dynamism Fund I	$46B firm committed capital (2025); $600M AD Fund I (2024)	Aerospace & defense, industrial/manufacturing, public safety, housing, supply chain	Seed–Growth	Hadrian (advanced manufacturing); AD thesis (defense/industrial)
Breakthrough Energy Ventures (BEV) — Funds I–III	~$3.2B across BEV I–III	Electricity, manufacturing, agriculture, industrial decarbonization	Seed–Growth	Commonwealth Fusion Systems; Form Energy; Electric Hydrogen; Boston Metal
DCVC (Data Collective)	Multi-billion AUM (~$4B)	AI + hard tech; space & autonomy; climate/energy; national security	Seed–Series B+	Oklo; Rocket Lab; Fervo Energy; Agility Robotics
Eclipse Ventures	~$4B AUM	Industrial/physical economy, advanced compute, supply chain, dual-use	Seed–Growth	Cerebras; Ursa Major; VulcanForms; Cellares
Founders Fund	~$17B AUM (2025)	Frontier tech & dual-use (space, autonomy, defense)	Seed–Growth	SpaceX; Palantir; Anduril (led $1.5B round in 2023)
Khosla Ventures	~$16B AUM (2025)	AI & compute; climate/energy (incl. fusion); health	Seed–Growth	OpenAI; Commonwealth Fusion Systems; NewLimit
Lux Capital	$5B+ AUM	Frontier science & engineering; autonomy, AI, advanced systems	Seed–Growth	Applied Intuition; Runway; Hugging Face
Playground Global	$1.2B+ AUM	Next-gen compute, AI hardware/software, automation, materials	Seed–Series A	Relativity Space; Skydio; MosaicML (acq. Databricks)
SOSV (IndieBio & HAX)	$1.5B AUM	Hard-tech (HAX); engineered biology/biomanufacturing (IndieBio); climate/health	Pre-seed–Series A	Formlabs; Opentrons; Upside Foods; Perfect Day
The Engine Ventures (MIT tough tech)	$1B+ AUM; Fund III $398M (2024)	Climate, human health, advanced systems & infrastructure	Pre-seed–Series A/B	Commonwealth Fusion Systems; Form Energy; Boston Metal

Interpretation notes. AUM figures reflect the latest public statements during 2020–2025. Some firms disclose firm-level AUM while others disclose vehicle sizes; both are shown as applicable. Representative portfolios are illustrative, not exhaustive.

Appendix B: Deep-Tech Funding Data Analysis (2020-2024)

Methodology

To empirically validate the "missing middle" financing gap identified through investor interviews, we conducted a quantitative analysis of deep-tech funding patterns using Crunchbase data. Our sample included 1,098 U.S.-based companies across five strategic hardware sectors: semiconductors, battery technology, quantum computing, advanced manufacturing, and robotics. We tracked all funding rounds from January 1, 2020 through December 31, 2024, filtering for rounds of $1 million or greater to focus on institutional venture capital activity and exclude angel investments that follow different dynamics.

For each company, we recorded the funding round type (Pre-Seed, Seed, Series A, Series B, Series C, etc.), total capital raised, and announcement date. We then aggregated funding data by stage, grouping Series C through Series I rounds into a "Growth" category to reflect the transition from first-of-a-kind facility development (typically Series B) to commercial scaling (Series C+).

Aggregate Funding Data by Stage

Stage	Total Funding (2020-2024)	Number of Deals	Average Deal Size
Pre-Seed	$150.4M	58	$2.6M
Seed	$2.04B	357	$5.7M
Series A	$8.48B	294	$28.8M
Series B	$10.63B	205	$51.9M
Growth (Series C+)	$68.14B	184	$370.3M
Total	**$89.45B**	**1,098**	**$81.5M**

Year-over-Year Trends

Total Funding by Stage and Year (USD)

Stage	2020	2021	2022	2023	2024
Pre-Seed	$37.2M	$34.4M	$28.5M	$28.9M	$21.5M
Seed	$168.2M	$440.5M	$526.9M	$390.5M	$517.4M
Series A	$760.5M	$3.40B	$1.38B	$889.1M	$2.05B
Series B	$1.70B	$2.54B	$2.26B	$2.27B	$1.86B
Growth (C+)	$13.46B	$19.32B	$11.49B	$11.96B	$11.91B
Total	**$16.13B**	**$25.74B**	**$15.69B**	**$15.54B**	**$16.36B**

Number of Deals by Stage and Year

Stage	2020	2021	2022	2023	2024	Total
Pre-Seed	6	18	14	11	9	58
Seed	47	88	84	77	61	357
Series A	48	76	71	50	49	294
Series B	46	53	39	38	29	205
Growth (C+)	31	49	38	34	32	184
Total	**178**	**284**	**246**	**210**	**180**	**1,098**

NOTE: GROWTH (C+) AGGREGATES SERIES C (102 DEALS), SERIES D (48 DEALS), SERIES E (20 DEALS), SERIES F (9 DEALS), SERIES G (3 DEALS), SERIES H (3 DEALS), AND SERIES I (1 DEAL) ACROSS ALL YEARS.

Key Findings

1. **The Missing Middle Emerges at Series B:** Deal count declines 30% from Series A (294 deals) to Series B (205 deals), while average deal size increases 80% from $28.8 million to $51.9 million. This represents the inflection point where capital requirements for first-of-a-kind manufacturing facilities exceed what most early-stage venture funds can deploy, yet companies lack the operating history required for growth equity or infrastructure investors.
2. **Capital Requirements Spike at Growth Stage:** Average deal size jumps from $51.9 million at Series B to $370.3 million at Growth stage—a 7x increase. Only 184 Growth-stage deals occurred across the five-year period, compared to 294 Series A deals, demonstrating that fewer companies successfully navigate the transition from first-of-a-kind facilities to commercial manufacturing scale.
3. **Series B Deal Activity Declined 24% from 2023 to 2024:** Series B deals dropped from 38 in 2023 to 29 in 2024, representing a 24% decline and the sharpest year-over-year contraction of any stage. This occurred even as Seed and Series A activity remained relatively stable (77→61 Seed deals, representing a 21% decline; 50→49 Series A deals, essentially flat), suggesting the bottleneck worsened precisely at the stage where companies must prove manufacturing viability.
4. **Early-Stage Capital Remains Abundant:** Seed and Series A funding totaled $10.52 billion across 651 deals from 2020-2024, demonstrating continued investor appetite for early-stage deep-tech innovation. The constraint is not capital availability generally but rather structural mismatch at the specific transition point where prototype technologies must become commercial manufacturing operations.
5. **Growth Stage Concentration:** Growth-stage funding (Series C+) totaled $68.14 billion across just 184 deals, representing 76% of total capital deployed but only 17% of deal count. This extreme concentration reflects both the capital intensity of commercial manufacturing scale-up and the high failure rate of companies attempting to bridge the missing middle: only 184 of the 651 companies that

raised Seed or Series A funding (28%) successfully reached Growth-stage financing.

Sector Distribution

The 1,098 companies in our sample distributed across sectors as follows:

- **Semiconductors:** 28% of deals, 35% of total capital
- **Battery Technology:** 22% of deals, 26% of total capital
- **Advanced Manufacturing:** 21% of deals, 18% of total capital
- **Robotics:** 18% of deals, 13% of total capital
- **Quantum Computing:** 11% of deals, 8% of total capital

Semiconductor and battery companies commanded disproportionate capital shares relative to deal count, reflecting the capital-intensive nature of manufacturing in these sectors—precisely the domains where the missing middle gap creates greatest competitive vulnerability relative to Chinese state-backed competitors.

Data Limitations

This analysis relies on publicly disclosed funding rounds reported in Crunchbase. Actual funding activity may be higher due to:

- Undisclosed rounds, particularly common in defense-related deep-tech
- Non-dilutive government grants (SBIR, ARPA-E) not captured as funding rounds
- Convertible notes and other instruments that may not be reported as formal rounds
- Corporate venture investments sometimes excluded from databases
- Strategic acquisitions that may appear as funding events

Our $1 million minimum threshold excludes angel investments and very early-stage activity, which was intentional to focus analysis on institutional venture capital patterns relevant to the missing middle. Companies requiring $50-300 million for first-of-a-kind facilities represent a categorically different challenge than those operating at angel or micro-VC scale.

The analysis treats each funding round as an independent event, meaning companies that raised multiple rounds across different stages appear in multiple categories. This approach correctly captures the funding dynamics at each transition stage, which is the focus of our missing middle analysis.

Despite these limitations, the data clearly demonstrates the systematic pattern our investor interviews identified: abundant early-stage capital, declining deal counts at Series B, and dramatic capital requirement increases at Growth stage, i.e., the empirical signature of the missing middle financing gap.

Data accessed from Crunchbase Pro, September 2025. Analysis conducted by Institute for Security and Technology.

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