

ATOMS AND ALGORITHMS

AUSTRALIA'S NEW INNOVATION INFRASTRUCTURE

www.armhub.com.au



John H Howard, Cori Stewart

For decades, Australian innovation policy discourse has been organised around the valley of death, the gap where good ideas fail to become commercial products. This model, born in an era of physical manufacturing, looks dated. An algorithmic revolution driven by data, AI and quantum computing is fundamentally changing our understanding of how value is created, forcing a complete rethink of the linear path from the laboratory to the market.

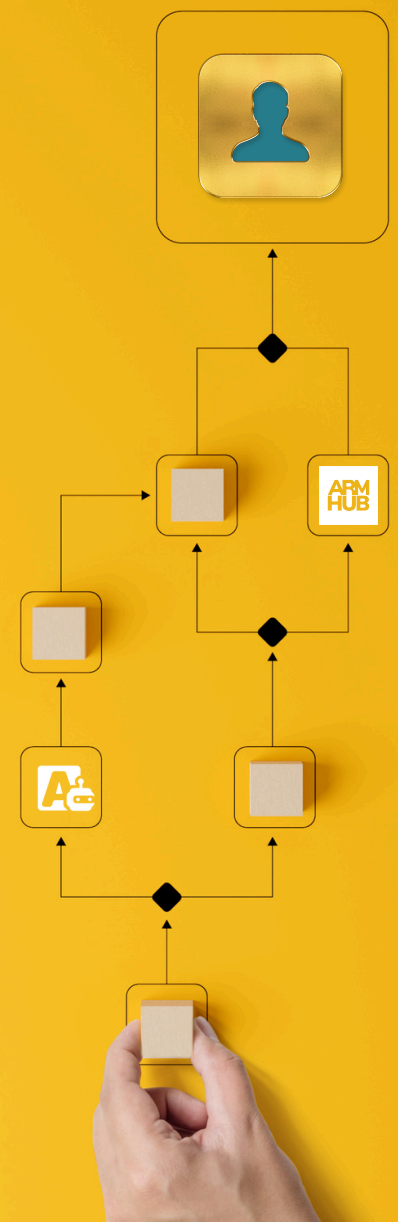
An Algorithmic Shift

The focus of value creation is shifting from 'atoms' to 'algorithms,' or more often, to algorithms that command the atoms.

Traditionally, success meant building a physical prototype and scaling its manufacture. Today, the most significant breakthroughs may exist entirely in code. DeepMind's AlphaFold, for instance, accomplished in months what traditional biology would have taken centuries to achieve.

This shift creates what we might call an 'infrastructure inversion.' Critical infrastructure is no longer limited to just laboratories and pilot plants. It is now computational power, massive datasets, and specialised talent to build new algorithms. This challenges traditional policy levers, ranging from R&D grants for facilities to patent systems designed for physical inventions.

The physical world remains relevant, but the valley of death has multiplied and morphed. We now face a computational valley (accessing data and computing) and an algorithm valley (turning theory into practical tools). The pathway from 'missions to markets' must now incorporate a new, parallel path: 'missions to code.' Success requires mastering both traditional physical pathways and new computational valleys.



Evidence from Australian Industries

The algorithmic shift is reshaping Australia's foundational industries. The infrastructure inversion and new algorithmic valleys are evident across many traditionally classified industrial sectors, including agriculture, construction, health, manufacturing, and resources.

Agriculture: The Algorithmic Paddock. Agriculture provides a clear hybrid model. The value lies not only in the autonomous tractor but also in the AI algorithm that guides it. Australian firms like [SwarmFarm Robotics](#) use AI for precision weeding, directly linking code to physical world action. Similarly, AI models analyse satellite and drone imagery to monitor crop health. The critical infrastructure here is data, ranging from satellite feeds to on-farm sensors.

Construction: The Algorithmic Blueprint. Even industries such as building and construction are undergoing this digital transformation. Traditionally focused on physical materials, the sector is discovering new value in algorithms. Digital twins and [Building Information Modelling](#) (BIM) create entire projects in code before a single foundation is poured. AI can optimise scheduling, manage site safety through computer vision, and guide robotic systems for assembly.

Manufacturing: The Digital Factory. This hybrid model is the very definition of advanced manufacturing. The paradigm moves beyond legacy factory floors to digitally native production. Value is created by robotics, digital twins, and AI-driven supply chains. The physical product is the output, but the competitive advantage lies in the algorithms that design it, test it through simulation, and build it with precision. This is another infrastructure inversion.

Health: From Diagnosis to Data. In healthcare, the algorithmic revolution is shifting innovation from the [lab bench to the database](#). The critical value is shifting towards algorithms that analyse medical images to detect cancers or utilise patient data to predict the onset of sepsis. The innovation's value resides in the model's predictive power. Australia's strategic advantage relies less on new hospitals and more on creating and using high-quality, ethically managed clinical datasets.

Resources: Code-Driven Extraction. Australia's resources sector applies these hybrid models, driven by the need for safety and efficiency. The innovation is not the giant haul truck; rather, it is the autonomous system that operates it. Rio Tinto's AutoHaul trains and BHP's autonomous drills are physical assets whose value is determined by algorithmic logic. A key piece of mining infrastructure is now BHP's [Integrated Remote Operations Centre](#) in Perth.

Policy Implications

This analysis raises important challenges regarding how Australian innovation policy is being conceived. Despite decades of effort, innovation and industrial policy remain inadequately defined as distinct areas. This has practical consequences that are now becoming urgent.

For example, there is a strong policy focus on manufacturing scale-up through initiatives such as the National Reconstruction Fund and the Future Made in Australia Initiative. This focus is vital, but the algorithmic shift clarifies how it should be approached. Policy must not be limited to legacy, factory-based models. It must support the deep digital transformation of advanced manufacturing.

The NRF's success will depend on its ability to fund the 'infrastructure inversion' in these sectors, such as the datasets and algorithms that will create the next wave of embodied robotics. The shift demands a re-evaluation of national research infrastructure. We must treat computational resources, massive datasets, and algorithmic expertise as critical public goods.

This transformation elevates talent as the primary strategic asset. National competitiveness will be determined by our ability to develop and attract elite talent in mathematics, computer science, engineering and quantum mechanics. We must also find new metrics for success beyond the number of patents filed. Australia's federal structure introduces coordination challenges.

The primary lever for talent will hopefully be the National AI Capability Plan, expected by the end of 2025, which is tasked with boosting AI skills. This builds on existing mechanisms, such as the National AI Centre and the AI Adopt Centres. The National Quantum Strategy (2023-2030) operates on a parallel track, with a core theme of building a skilled workforce.

Current Policy Response

Australian policy has begun to respond, though this strategic realignment remains incomplete. The response must be organised around three pillars: talent, data, and computation.

Recent reporting shows that China is now exporting an integrated automation ecosystem—machinery, software, engineering expertise, and production services—that is extremely difficult for other nations to constrain through traditional supply-chain or chokepoint strategies. Because this model is diffuse, software-led, and rapidly deployable, it is reshaping global manufacturing competition. For Australia, the implication is that we must reinforce our industrial base through strategic co-investment with industry and research partners, while keeping open the option of well-designed partnerships with China, particularly as Chinese firms are developing automation software that does not demand the vast data-centre and compute infrastructure currently being built in the United States.

This framing matters because it recognises that defensive trade barriers alone cannot address the structural challenges posed by automated manufacturing systems. Australia needs offensive capability, leveraging its competitive advantages, and building domestic capacity in the key technologies reshaping global production.

China's robot-driven export surge demonstrates that automation has become a comparative advantage in its own right. Countries that master industrial robotics and AI-enabled manufacturing gain market share, regardless of labour costs. This shifts the competitive dynamic away from traditional factor endowments toward technological capability and data infrastructure.

For Australia, these signals point to a clear strategic imperative: develop sovereign automation capabilities and data infrastructure to remain competitive. This represents the algorithmic thesis in action, where control of data and compute capacity determines industrial outcomes.

The Central Role of Data

Ownership, Access, and Infrastructure

Effective policy requires clear design principles, governance, and a strong economic rationale for data infrastructure. A National Industrial Data Commons, governed as a fiduciary trust by both government and industry, is needed to provide the necessary institutional architecture. This body would aggregate and anonymise operational data, ensure interoperability, and, importantly, enable commercial viability. Tiered access models can serve different user needs. The case for action rests on a simple reality: without shared, high-quality industrial datasets, algorithms cannot scale beyond pilots. Models like ARM Hub's Data and AI-as-a-Service, which enables "data plumbing" for industry, exemplify this essential first step.

This approach is essential. As numerous recent reports have pointed out, many firms have bought AI tools, but few winners have rebuilt their work and workflows. Agentic AI pilots show promise, but without workflow redesign and data integration, they support demonstrations rather than achieving outcomes. The companies that rewire will beat those that simply "roll out". This infrastructure should be positioned within the Future Made in Australia framework.

The Critical Gap

Investment in computation is happening on two fronts: quantum computing and classical high-performance computing (HPC). The National Quantum Strategy is backed by the National Reconstruction Fund's \$1 billion allocation for critical technologies.

However, an urgent challenge exists in traditional HPC. The Australian Academy of Science has warned that our national supercomputers are ageing. This gap is recognised, and the National AI Capability Plan is tasked with identifying infrastructure needs.

Australia must secure its own data and compute capacity to avoid dependency on any single source. Relying on either US commercial infrastructure or potential Chinese industrial data systems creates strategic vulnerabilities. Building sovereign capability in data infrastructure is a matter of national interest.

The Robotics and Embodied AI Frontier

The infrastructure required for embodied AI differs from conventional computing infrastructure. It demands physical spaces where robots can be tested, trained, and validated alongside human workers. It requires simulation environments that can model real-world conditions with sufficient accuracy to transfer learning from virtual to physical systems.

Most importantly, it needs governance frameworks that address safety, liability, and workforce transition in ways that build public confidence. Global investment trajectories now position humanoid and embodied AI as the next frontier in computing. Recent large-scale funding rounds and China's plans for mass production demonstrate the rapid convergence of AI and robotics.

NVIDIA's frameworks define the tooling that will enable this transition. In Australia, ARM Hub's AI Adopt Centre's current agentic AI capability provides intelligent decision-making for manufacturing operations. The next evolution, embodied AI, extends this intelligence into the physical world through robotic systems.

ARM Hub's proposed Embodied AI Adopt Program will be a national demonstration model. The connection between digital twins, simulation, and physical AI systems is where technology meets the real economy. The link between blue-collar workforce development and regional manufacturing centres is fundamental to this evolution. This is how AI becomes everyone's tool.



Fundamental: Regional manufacturing centres powering an evolution
Prof Cori Stewart with Mayor John Raven at Build Logan 2025

Beyond Big Tech: The US-China Robotics Divide

There is a strategic contest shaping global algorithmic dominance. Recent reporting highlights China's state-backed push to export a nanofabrication-first production model, including government-owned centres for "robot teaching factories" and humanoid robotics innovation. These facilities generate and own industrial data, embedding learning loops into national industrial policy.

The United States maintains a different form of dominance. US entities control most private AI investment and compute infrastructure through companies such as NVIDIA, AWS, and OpenAI.

Universities vs, Industry Infrastructure

A distinction must be made between university and industry infrastructure. University systems, like the ARDC, are optimised for research rather than the demands of industrial service-level agreements or commercial uptime. A clear delineation of roles is necessary: universities should focus on methods, benchmarking, and skills development.

Conversely, industry and independent hubs should handle data operations, deployment, and scaling. This suggests a need for dedicated funding streams for industry-run data infrastructure, backed by sovereign compute providers.



Industry and education: serving innovation with distinctly different roles
Prof Cori Stewart at NIPF 2025

The Role of Place-Based Innovation

The algorithmic shift reframes the importance of physical places. Effective ecosystems are emerging nationally. Examples include Tech Central in Sydney, Adelaide's Lot Fourteen, Gold Coast's Health and Knowledge Precinct, the Geelong Future Economy Precinct, Perth's Australian Automation and Robotics Precinct, and the Advanced Manufacturing Readiness Facility at Bradfield. They all physically co-locate human infrastructure (talent) with algorithmic infrastructure (data and compute).

Adelaide's Lot Fourteen, for example, houses the Australian Institute for Machine Learning alongside tech giants. This represents a new logic: national infrastructure (the algorithmic engine) is integrated with place-based precincts (the human interface). Many current proposals for AI factories explicitly state that these national assets should be co-located with research institutions and innovation precincts.

These AI Factories must be focused on measuring operational data flow, rather than describing physical presence. Precinct success should be measured by terabytes of data ingested, the number of deployed robotics systems, digital twins, and SME AI uptake. Case studies, such as ARM Hub's Northgate facility, demonstrate integrated data pipelines for industrial firms.

These AI-intensive precincts should reflect the premise: data-first, compute-enabled, and commercially viable. In this context, current espoused public policies may be misreading the tea leaves. Building data centres, which is where a lot of policy is going at the moment, with State Governments and Precinct managers supporting construction in their areas, is not where the asset is. The asset is the datasets. Without datasets that will allow Australia to create IP and industry, we will have another form of "dig and ship", but this time, compute power, which we have not managed to value-add to Australian industry.

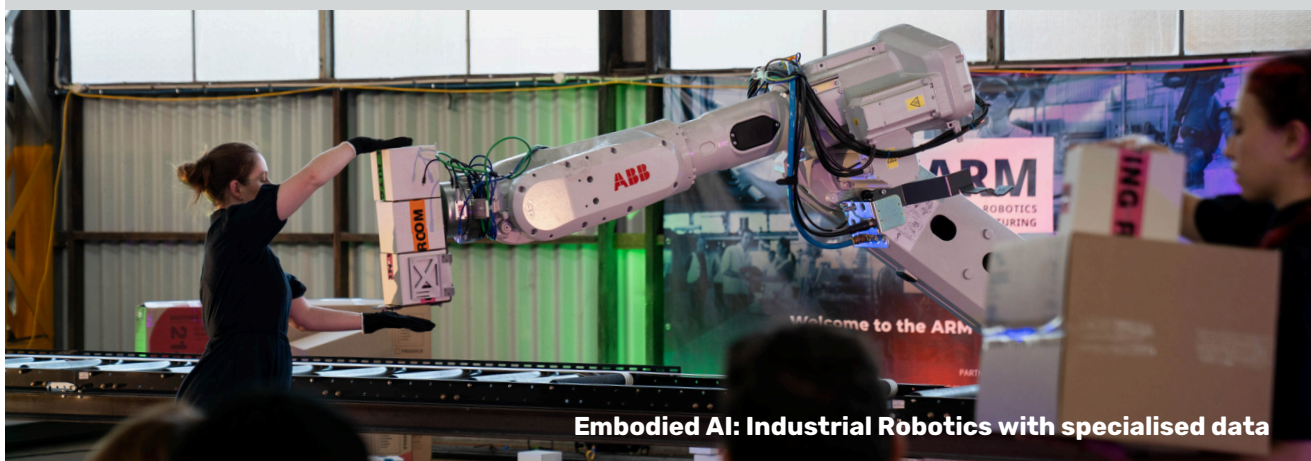
The World Model Debate: Scale Versus Specialisation

Tech giants pursuing comprehensive world models may be solving the wrong problem for industrial deployment. The generative AI experience suggests that while companies like OpenAI have pursued ever-larger language models, practical value often emerged from smaller, specialised models fine-tuned for specific tasks. A model explicitly trained for legal document analysis typically outperforms a general-purpose giant for that application.

This pattern applies even more strongly to embodied AI. Industrial robotics does not necessarily need systems that understand every possible physical environment. A warehouse robot needs to navigate warehouses reliably. A manufacturing robot must manipulate specific components in a controlled environment. Each operates in relatively constrained, predictable contexts where specialised understanding matters more than general capability.

If specialised models prove more practical than world models, value creation shifts from centralised AI developers toward distributed applications developed in partnership with industrial users. A logistics company working with robotics specialists to optimise warehouse operations does not need a universal system. It needs reliable performance for its particular layout, inventory types, and workflow patterns.

In any event, industrial transformation might not wait for universal world models. It could emerge from accumulated incremental improvements in specialised systems, each addressing specific operational challenges. This aligns with how technological change typically diffuses through economies: through adapted implementations shaped by particular operational contexts rather than revolutionary breakthroughs deployed universally.



Embodied AI: Industrial Robotics with specialised data

Lessons from the National Innovation and Science Agenda

The 2015 National Innovation and Science Agenda (NISA), the most recent national innovation strategy, provides instructive lessons. Evaluation shows that its targeted interventions ignited the startup ecosystem, but its broader narrative failed to secure long-term political commitment. But significantly, it failed to address the gathering storm clouds of digital transformation.

NISA's most lasting success was its package of capital reforms. Reforms to Venture Capital Limited Partnerships and tax incentives unleashed a wave of private capital. The 'Ideas Boom' slogan shifted the national conversation, and programs like CSIRO's ON Accelerator were influential. The VCLPs and ESVCLPs supported numerous startups in the technology space, but we are now confronting a bottleneck in scaling up and development capital.

The primary failure of NISA was political. The 'Ideas Boom' rhetoric was abandoned, creating a policy vacuum. The narrative, which was purely economic, failed to capture the public's imagination. It was perceived as a policy for the elite, for entrepreneurs in inner-city hubs, rather than for ordinary Australians or blue-collar workers. This made it politically disposable.

The contemporary algorithmic narrative departs from NISA by redefining the assets and infrastructure. NISA's hero asset was the startup. The hero asset of the new narrative is the algorithm, the trained model, or the proprietary dataset. NISA's valley of death was a lack of capital; the new narrative identifies algorithmic valleys: gaps in accessing data, computation, and talent.

The algorithmic narrative provides a way to bridge the political gap that NISA faced. By focusing on the digital transformation of foundational industries such as advanced manufacturing and construction, it connects the 'algorithm' directly to traditional sectors and regional jobs. This makes the policy tangible by linking code to physical outcomes in industries that people understand.

The journey from analysis to industry evidence confirms a fundamental shift; the old linear model from lab to market is no longer sufficient. Australia's key industries—from health and agriculture to resources, advanced manufacturing, and construction—are already navigating this new reality.

In response, Australian policy is beginning to develop new critical infrastructure. The focus is shifting toward talent and data. However, this realignment remains slow and incomplete. The infrastructure inversion means that computational power is as essential as laboratories. A pressing and immediate gap exists: national classical high-performance computing systems are ageing.

The Path Ahead

1

Australia must make **urgent decisions** regarding its **sovereign computational capability**. The quantum future matters, but the classical computing present demands immediate investment.

2

We must **develop new frameworks** for **collecting, aggregating** and **valuing datasets** and algorithmic assets.

3

Coordination and collaboration **mechanisms** across federal and state boundaries must be **strengthened**.

Success will depend on strategically uniting talent, data, and compute capabilities. This requires moving beyond episodic announcements to sustained, integrated investment in computational infrastructure as a national priority. The paradigm has shifted. The question is whether policy frameworks will shift with sufficient speed.