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Singapore's AI Ecosystem
Research, development, and governance
ESF Research Report

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SINGAPORE'S AI ECOSYSTEM

RESEARCH, DEVELOPMENT, AND GOVERNANCE

ESF Research Report

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Content

1 Introduction

Research and development in Artificial Intelligence (AI) have enabled a wide range of applications that are transforming society, industry, and public governance. The emergence of generative AI chatbots, such as ChatGPT, Claude, Google Gemini, and Microsoft Copilot, has further broadened access to these technologies, heightening public awareness and interest. Such advances have further accelerated both the development and adoption of applied AI. At the same time, it has heightened awareness of the potential risks these technologies pose. As a result, governments around the world now face the challenge of promoting innovation and encouraging adoption whilst simultaneously establishing effective governance frameworks.

Singapore, since the launch of its first National AI Strategy in 2019 has evolved into a global leader in the AI sphere. It has successfully built a thriving AI community that connects its research institutions, industry stakeholders, and public institutions, thereby promoting collaboration and the sharing of knowledge and expertise. Parallel to these efforts, the city-state was among the first countries to address the emerging risks of AI, launching the first edition of its Model AI Governance Framework in 2019. As a result, Singapore provides opportunities for collaboration with European partners and Singapore's experiences in building its national AI ecosystem offer valuable lessons.

This research report outlines Singapore's approach to AI ecosystem development, focusing on its research environment, its priorities and strengths in applied AI, and its approach to AI governance. Doing so provides an overview of Singapore's key lessons learned and highlights opportunities for collaboration with European partners. By outlining Singapore's strengths, priorities, and approaches to AI development and governance, this research helps share those insights and supports future partnerships with European stakeholders. The overviews presented here draw on analyses of relevant policy initiatives and literature, as well as interviews with academic experts, industry leaders, and policy professionals. In addition, data and tools from the Emerging Technology Observatory were used in Sections 3 and 4a to analyse Singapore's AI research productivity and related patenting activity. Additionally, the research findings were shared and discussed during an expert roundtable. This report presents those research findings. Section 2 outlines the relevant policy background, Section 3 examines Singapore's AI research ecosystem, Section 4 explores the current state of AI technology developments, and Section 5 provides an overview of Singapore's approach to AI governance.

2 Tech policy in Singapore

Singapore's five-year Research, Innovation, and Enterprise (RIE) plans outline the nation's R&D priorities. Built on the pillars of scientific research, technology translation, and industry development, these strategies provide a long-term vision in maintaining and expanding Singapore's position as a global innovation hub. Starting with RIE 2020, launched in 2016, the plans have been structured around four domains: manufacturing, health, urban solutions, and digital economy.

While AI technologies are anticipated to impact each domain; they are of particular importance in the context of the digital economy. This domain, referred to as Smart Nation and Digital Economy (SNDE) in RIE2025, drives the nation's continued efforts towards developing its digital economy, digital government, and digital society. To this end, Singapore adopts a whole-of-nation approach, leveraging academia, industry and government to advance emerging technologies such as explainable AI, small data techniques, and federated learning.[1] The RIE plans not only support research into such technologies, but also align the nation's R&D ecosystem with industry needs to increase the speed-to-market of innovations enabled by new knowledge generated through scientific research.

Smart Nation and Digital Economy

The Smart Nation and Digital Economy domain drives Singapore's national digital transformation effort, which was launched in 2014 with the Smart Nation initiative. Originally, this initiative focused on developing new capabilities; however, the release of Smart Nation 2.0 in 2024 marked a transition towards the application of those capabilities. To this end, Smart Nation 2.0 is centred around three core goals: Trust, Growth, and Community. These goals serve the initiative's underlying principle: technologies must be reliable and inspire confidence in their users.[2] Through the Smart Nation initiative, Singapore therefore aims to enable individuals and businesses to adopt, connect through, and trust these technologies.

AI technologies are considered to be essential in achieving these objectives, which is why Singapore has designated AI development as a strategic national priority.[3] Smart Nation 2.0 reflects this through its strong emphasis on the development, adoption, and application of AI. While AI is relevant across the Smart Nation goals of Trust and Community, it is especially critical in relation to Growth. In this respect, Singapore seeks to leverage AI to boost productivity and enhance its competitiveness.[4] At the same time, the Smart Nation initiative also recognises that AI presents new challenges. These include the possibility that AI tools could make scams or manipulative campaigns more effective or create new avenues for online fraud.[5] These concerns are addressed mainly within the Smart Nation goals of Trust and Community.

National AI Strategy

Recognising AI's importance and potential for its Smart Nation ambitions, Singapore launched its first National AI strategy in 2019. Following the GenAI boom, Singapore updated its strategy, launching the National AI Strategy 2.0 (NAIS 2.0) in 2023. This strategy sets out Singapore's AI ambitions and the measures required to achieve them over a three-to-five-year period. Its objectives include the building of

1 See for example National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 65, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025) and Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) p 79, https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025)

2 Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) p 26, https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025).

3 Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) p 50, https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025).

4 Public First, Singapore's AI Opportunity: How AI Can Power Singapore's Future (Public First 2025) p 9, https://aiopportunity.publicfirst.co/reports/Singapore%20AI%20Opportunity.pdf (last accessed 28 November 2025); National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 6, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025).

5 Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) p 34, https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025).

a strong local AI ecosystem and using the technology to address labour and productivity challenges. To achieve this, Singapore emphasises the preparation of its workforce and industries through education and training. NAIS 2.0 further outlines the risks of widespread AI use, including more efficient scams, cyberattacks and misinformation campaigns.[6]

Compared to the first iteration, NAIS 2.0 introduces three key changes to Singapore's AI strategy. First, AI is considered a necessity rather than an opportunity. NAIS 2.0 defines AI as a general-purpose technology that will play a pivotal role in advancing Singapore's Smart Nation as a whole, requiring a broad proficient user base.[7] Second, the Strategy adopts a global perspective by emphasising the need to engage with international innovation networks and to help address AI-specific challenges such as high energy use and limited data availability.[8] Third, NAIS 2.0 moves beyond a project-based strategy to adopt a more systemic approach.[9] This acknowledges that the successful realisation of Singapore's AI ambitions depends on the active participation of diverse stakeholders across sectors, both within and outside the country.

It does so by connecting industry, government and research institutions to identify and address meaningful use cases that require broad expertise and hold the potential to transform the economy and society.[10] As part of its approach, the Strategy outlines the creation of essential infrastructure and the provision of support for critical stakeholders, such as top researchers, engineers, and industry partners.[11] By bringing together industry, government, and research institutions to identify and address relevant use cases, the Strategy seeks to generate new knowledge and translate it into concrete solutions. Through this, NAIS 2.0 builds an environment where innovation can be scaled and benefits can be maximised. Finally, the Strategy emphasises the importance of establishing a regulatory environment that supports trust in AI technologies amongst both citizens and industry.[12]

Developing AI capabilities

Scientific research plays a key role in developing AI capabilities by producing new knowledge that enables the creation of novel applications or the improvement of existing ones. To ensure this work aligns with societal needs, Singapore encourages collaborations between researchers and industry partners by providing infrastructure, access to data, and financial support, thereby steering these efforts in line with NAIS 2.0's key domains. These domains include developing Singapore's leading economic sectors, such as financial services, manufacturing, and health, its Smart Nation Priorities, as well as cross-cutting

6 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 55, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025).

7 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 5, available online https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025).

8 Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) pp 48-53, https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025).

9 Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) p 10, https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025).

10 Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) p 14 https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025).

11 Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) p 18, https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025).

12 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 56, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025).

capabilities.[13] This latter domain covers areas where AI can optimise and transform business functions (or 'AI for business operations'), where it can accelerate research productivity across scientific fields (or 'AI for Science'), and where further scientific progress is needed to enhance AI's capabilities (or 'foundational AI').

Foundational AI is aimed at making AI technologies less costly, suitable for broad adoption, and trustworthy. To this end, the Strategy sets out three key research priorities:

- Reasoning AI - Research focused on improving how AI systems understand logical and physical concepts and how they explain their results.
- Resource-efficient AI – Research to reduce AI's reliance on data and compute.
- Responsible AI – Research aimed at reducing the risks created by AI and making sure it is trustworthy, safe, and secure.

Translating such research through 'AI for Science' and 'AI for Business Operations' requires the identification of clear and actionable problems, the development of use cases, and a workforce ready to use it. Singapore has defined three actions to accomplish this.[14] First, it seeks to attract and develop top AI talent, including researchers and engineers who will advance next-generation AI research and applications. Second, the Strategy focuses on increasing the number of 'AI practitioners,' workers with the expertise to create, implement, and scale AI solutions. Third, it emphasises equipping enterprises and workers to become confident users of AI.

Ensuring the necessary support

In addition to a facilitative environment, realising these AI ambitions requires high-tech infrastructure, a considerable supply of chips capable of providing the necessary compute, and access to substantial datasets. With this in mind, Singapore sets out to substantially expand its computing capacity. In parallel, it aims to leverage both the open-source movement and private-sector data marketplaces to address constraints on data availability. Singapore's government will support this by selectively releasing public-sector datasets for AI development. At the same time, the city-state seeks to maximise the value of existing data by improving its quality, ensuring it is context-appropriate, and embedding it within trusted data sharing frameworks.

NAIS 2.0 furthermore underscores that providing an environment conducive to AI development depends on the robustness and safety of AI technologies. This, in turn, requires the creation of AI-specific governance and security frameworks.[15] These frameworks must support innovation and experimentation while also ensuring development remains safe and responsible. At its core, the aim is to develop AI systems that are reliable and resilient, ensuring they remain unbiased, accurate, and capable of producing correct outputs.

13 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 18, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025). .

14 Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) p 33, https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025).

15 Ministry of Digital Development and Information, Smart Nation 2.0: A Thriving Digital Future for All (October 2024) p 54, https://file.go.gov.sg/smartnation2-report.pdf (last accessed 28 November 2025).

3 AI research in Singapore

Singapore's National AI strategy illustrates how the nation's AI vision goes beyond industry development, requiring new knowledge generated through future scientific discoveries. To achieve this, the AI research ecosystem has become a cornerstone of the country's AI ambitions. Three recurrent themes regarding this research ecosystem emerged from the interviews. First, the government provides substantial funding for AI research. Such funding, according to interviewed AI researchers, is provided in a transparent manner and is relatively accessible. This has created a research environment in which administrative burdens are limited, top-tier talent is available, and infrastructure is good. The second recurrent theme is Singapore's long-term vision for AI. Serving as a roadmap, this vision orients the research community. One participant described this as 'a direction, rather than steering: a pleasant environment to work in.' The third theme concerns the presence of world-class universities in Singapore, concentrating significant expertise in a small geographic space. This makes collaboration and knowledge exchange easier, while also encouraging a pragmatic research culture that some found missing in foreign institutions.

Across the interviews, participants highlighted the growing importance of interdisciplinarity in AI research, noting that the field increasingly intersects with other fields such as economics, linguistics, psychology, and law. As more applications of AI technologies are developed and the attention for AI-related risks continues to grow, the importance of multidisciplinarity in AI research is expected to increase. This is especially relevant in Singapore, where the strong focus on safe, responsible, and trustworthy AI development makes interdisciplinarity even more critical, since ethical, legal, and social perspectives must be integrated with technical expertise.

When asked about obstacles facing Singapore's AI research community, participants pointed to the limited availability of large datasets and compute. While these are global bottlenecks in AI development, they pose particular difficulties for Singapore. With regard to the limited availability of relevant data, Singapore's emphasis on localised AI (see section 4c for more on this), motivated in large part by the need to reflect the nation's cultural diversity, requires highly context-specific datasets that are scarce. The availability of compute is subject to similar constraints, as Singapore's small geographic size restricts space for data centres, and its tropical climate makes conventional cooling techniques less effective and more expensive. Additionally, several participants highlighted the difficulties in recruiting talent, as potential employees possess in-demand skills and BigTech companies can offer significantly higher salaries. As a result, recruitment and retention of staff, especially in academia, therefore present a considerable challenge.

Research directions

Singapore's AI research community is central in advancing the nation's AI ambitions. Its research produces new knowledge that informs industry, thereby driving the development of novel AI applications. Through the Emerging Technology Observatory's (ETO) tools, one can obtain a general overview of how Singapore's AI research community performs.[16]

16 Emerging Technology Observatory, Country Activity Tracker: Artificial Intelligence, https://cat.eto.tech (last accessed 28 November 2025); Emerging Technology Observatory, Map of Science, https://sciencemap.eto.tech (last accessed 28 November 2025).

The ETO was launched in October 2022 by the Center for Security and Emerging Technology at Georgetown University's Walsh School of Foreign Service. This Center conducts data-driven research on the security implications of emerging technologies, including AI, advanced computing, and biotechnology. Through the ETO, it offers publicly accessible data resources designed to inform critical decisions on technology policy. This platform, a non-profit initiative, compiles both commercial and public-domain data and provides online tools for analysing these datasets.

The Country Activity Tracker is one such tool, offering a dashboard for tracking and comparing AI-related activity in areas such as research, patents, and investment. It is powered by a dataset derived from the Merged Academic Corpus (MAC), which was created and is maintained by the ETO. The MAC contains deduplicated records from more than 270 million academic articles, drawing on sources such as Clarivate Web of Science, arXiv, Semantic Scholar, and other open-access platforms. It also integrates the Lens's patent dataset to capture patenting activity linked to academic output. Each article's title, abstract, and keywords are assessed by an automated, classifier-based process to determine whether it is AI-related. When relevant, the article is also assigned to an AI subfield.[17] Articles are then linked to countries via the authors' institutional affiliations in the MAC metadata. For example, a paper authored by a researcher at the National University of Singapore is assigned to Singapore. This allows the Country Activity Tracker to compare Singapore's AI research with that of other countries and to rank it by publication volume and citation impact, both overall and within specific subfields.[18]

Field of study	Publication volume	Citation impact
AI Safety	13th	10th
Computer Vision	15th	11th
Large Language Models	9th	8th
Natural Language Processing	17th	9th
Robotics	19th	15th
Overall	**18th**	**13th**

Singapore ranks eighteenth worldwide in overall AI publication volume, with more articles in the past decade than Switzerland, Turkey, and Malaysia. Its work is also well cited: Singapore places thirteenth in citation impact, surpassing countries such as the Netherlands, Japan, and Spain in total number of citations. The subfield breakdown indicates that most of Singapore's research output is in large language models, AI safety and computer vision. Its most frequently cited work, however, lies in large language models, natural language processing, and AI safety.

17 Subfields include AI Safety, Computer Vision, Large Language Models, Natural Language Processing, and Robotics.

18 Resp. the total number of AI articles published by authors in a specific country during the last decade and the total number of citations of those articles.

Research areas

Another tool provided by the ETO, the Map of Science, offers more detailed insights into the specific research areas where Singapore's AI community excels. While both the Country Activity Tracker and the Map of Science draw on data from the MAC, the Map of Science provides a more detailed picture by clustering articles based on their citations and how often they reference one another. Through this process the ETO has identified a set of 85.000 research clusters. Metadata is then generated for each cluster through an analysis of article titles, abstracts, and key concepts in addition to citation links. The metadata encompasses a range of information, including the high-level research field (such as medicine or computer science), the cluster's key concepts, and the three countries linked to most articles within a cluster. The MAC's metadata specifies for each article whether it is AI-related. Using this information, clusters are assigned an AI percentage that represents the proportion of AI-related articles they contain. As a result, this tool can be used to identify the AI-focused research clusters where Singapore's research community is most active, specifically those in which it ranks among the top three countries by authorship.[19] The Map of Science reveals eight such clusters, seven in computer science and one in mathematics.

Gradient-based minimax optimisation

This research cluster concerns mathematical research into gradient-based minimax optimisation problems such as nonconvex–nonconcave problems.[20] This research could underpin improved optimisation techniques in adversarial learning and multi-agent reinforcement learning. Through this, the cluster could support the development of machine learning solutions that better reflect the real-world scenarios in which the technology is likely to be applied. Traditional methods like gradient descent perform best under specific conditions which often do not hold in practical applications, leading to suboptimal performance. Alternative optimisation algorithms explored in this cluster include, for example, extragradient and optimistic gradient methods, anchoring/accelerated schemes, and simple single-loop variants that aim for stable, often faster, and sometimes last-iterate convergence. According to the Map of Science, Singapore University of Technology and Design is the leading global contributor of scientific publications in this research area.

Episodic memory

The research cluster on episodic memory is mainly focused on enabling robots to encode, store, retrieve, and express experiences in a transparent and adaptable manner, with the goal of enabling more symbiotic human-robot interactions.[21] Such research might explore brain-inspired memory models that use hierarchical clustering and Adaptive Resonance Theory (ART)–based networks to structure and retrieve memories contextually, thereby effectively encoding experiences as clusters of semantic elements (such as people, activities, places, times, and objects). Other research might instead focus on enabling robots to express and explain their behaviour using natural language. By combining insights from research on robot verbalisation and deep episodic memory architectures, this line of research could enhance a robot's ability to learn from experiences. This could also enable robots to express and

19 This study defines 'AI-focused research clusters' as clusters with an AI percentage of 50% or higher.
20 Map of Science Cluster ID 64740, Available online: sciencemap.eto.tech/cluster/?version=2&cluster_id= 64740 (last accessed 28 November 2025).
21 Map of Science, Cluster ID: 62587, Available online: sciencemap.eto.tech/cluster/?version=2&cluster_id=62587 (last accessed 28 November 2025).

explain those experiences in a meaningful way, thereby improving transparency and explainability. The Map of Science identifies Singapore Management University and Nanyang Technological University as global leaders in this research area, both in total publications and average yearly citations.

Applying machine learning to combinatorial optimisation problems

Applying machine learning to combinatorial optimisation problems could ultimately prove valuable in developing solutions to a wide range of logistical and planning challenges.[22] These include, for example, manufacturing and production scheduling, infrastructure planning, and delivery optimisation. Research in this cluster is mostly focused on routing problems, such as the vehicle routing problem, which seeks to determine the most efficient paths for a fleet of vehicles to deliver goods to multiple destinations. While such problems can be solved through traditional methods, these methods often scale poorly and are typically tailored to specific scenarios. This research cluster explores the integration of machine learning with traditional combinatorial algorithms to address such inefficiencies or to develop more general solutions. Three of Singapore's Universities are amongst the top ten most productive institutions in this research cluster, including Nanyang Technological University, National University of Singapore, and Singapore Management University.

Human-object interaction and scene graph generation

Research in the context of this cluster explores methods for interpreting complex visual scenes in computer vision by detecting individual objects, their relationships, and their interactions.[23] As such, this cluster is especially concerned with scene graph generation, which constructs image representations by identifying objects, their attributes, and their relationships. For example, in an image of a person with a surfboard on a rock in front of a beach, the system detects objects such as the person, the rock, the surfboard, and a wave. It then identifies attributes (e.g., the surfboard is red, the rock is large) and relations/predicates (e.g., the surfboard is being held, man standing on rock, person holding surfboard, wave near rock). Together, these form a structured representation of the scene as a graph.

An important focus within this research is human-object interaction. Research in this area is closely related to scene graph generation, as it focuses on the actions or relationships between objects and persons in a visual scene. For instance, a system may identify the person walking down the rock whilst holding the surfboard. Such research moves beyond detection-classification pipelines and in many recent works employs transformer-based architectures to model interactions more holistically, though two-stage and hybrid designs also remain widely studied. This research addresses fundamental challenges in human-object interaction and scene graph generation, such as the need for contextual reasoning and the issue of imbalanced data caused by the overrepresentation of frequent interactions. Researchers active in this cluster may work on overcoming such challenges through the application of graph neural networks, query-based pair detection, or data rebalancing techniques. In Singapore, most of the research in this area is conducted at the National University of Singapore.

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22 Map of Science, Cluster ID: 70717, Available online: sciencemap.eto.tech/cluster/?version=2&cluster_id=70717 (last accessed 28 November 2025).
23 Map of Science, Cluster ID: 37415, Available online: science-map.eto.tech/cluster/?version=2&cluster_id=37415 (last accessed 28 November 2025).

Event extraction

The process of understanding text involves converting it from an unstructured form into a structured representation of events.[24] This research cluster develops techniques for detecting, identifying, and describing such events. This process, known as event extraction, is essential in natural language processing because it allows AI to answer questions, retrieve information, and build knowledge bases. Research conducted within this cluster aims to develop more flexible, scalable, and generative approaches that often operate at the document level as well as the sentence level, and aim to reduce dependence on annotated data. For instance, from the sentence 'she is figuring out if the waves are decent for longboarding,' an event extraction system might identify the event (evaluating surf conditions), the trigger word that signals the event, and the roles such as Agent (she), Object (waves), and Context (longboarding), with the understanding that roles vary by event type. Document-level event extraction could combine contextual information, linking who is evaluating the conditions, what kind of waves are being considered, and which type of board, to build a richer, structured account of the event while reducing, rather than eliminating, reliance on annotated training data. This research explores generation-based and sequence-to-structure methods, as well as the use of prompt learning and prefix tuning to incorporate type-specific or contextual information into pre-trained models.

Sentiment analysis

The research cluster on sentiment analysis focuses on computationally identifying and classifying the subtleties of human emotions.[25] It does so by moving beyond traditional three-class models that categorise text as positive, neutral, or negative. This line of research explores solutions inspired by human cognition, enabling a more nuanced, human-like understanding of emotions that can recognise the intensity of emotions and incorporate contextual nuances.

A common theme in this research is the development of explainable sentiment analysis tools. One approach involves using a multi-level modular structure that mirrors the process by which humans understand language. The integration of multiple knowledge bases, which serve as structured repositories of information for guiding models' decisions, makes it possible to perform fine-grained, multiclass sentiment classification. By using identifiable components, this method makes it possible to explain the reasoning behind a particular sentiment assignment. For instance, when analysing the sentence 'he was looking forward to surfing, but almost slipped when walking down the rock,' the system can separate the positive sentiment associated with looking forward to surfing from the negative sentiment tied to almost slipping. Drawing on knowledge bases, it identifies both emotions, classifies the overall sentiment as mixed, and can explain that the positive classification comes from anticipation of surfing while the negative classification arises from nearly slipping.

An alternative approach generalises language into a form of 'proto-language' by converting input into semantic primitives. These primitives are then linked to emotion and polarity labels via a commonsense knowledge graph using the Hourglass model. This neurosymbolic approach ensures explainability by

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24 Map of Science, Cluster ID: 34496, Available online: science-map.eto.tech/cluster/?version=2&cluster_id= 34496 (last accessed 28 November 2025).

25 Map of Science, Cluster ID: 40471, Available online: science-map.eto.tech/cluster/?version=2&cluster_id= 40471 (last accessed 28 November 2025).

making the generalization process transparent and linking final classifications to both emotional states and the underlying concepts that express them. Much of the expertise in this area is concentrated within the Sentic Team at Nanyang Technological University, the most productive institution worldwide in this research area.

Collaborative semantic mapping and SLAM

This research cluster focuses on enabling autonomous robots to collaboratively create maps of their environment that are both consistent and semantically rich.[26] This cluster builds on traditional SLAM research by emphasising multi-agent settings. For example, multiple autonomous robots can be used to explore a disaster site. Each robot can explore a different section, and by sharing their data, they can create a single consistent map of the area that highlights key features such as collapsed buildings and blocked roads.

Key challenges focused on by research within this cluster relate to perceiving, sharing, and merging geometric and semantic data in real-time. This cluster is particularly concerned with challenges that are unique to multi-agent systems, such as limited communication, unstructured or dynamic environments, and heterogeneous sensor configurations. A central theme of this research is the alignment and integration of maps produced by different agents. Because each agent contributes a unique perspective, achieving a consistent shared representation is inherently difficult. This challenge is often exacerbated by differences in sensors, sensor inputs, and semantic interpretations. To address this, the research in this cluster develops hierarchical and probabilistic semantic mapping frameworks that support more reliable alignment across agents. Research in this cluster explores solutions such as map fusion algorithms, deep learning-based segmentation, distributed SLAM architectures, and multimodal sensor fusion.

Biohybrid insects

This final cluster works on integrating electronic systems into living animals to form cyborg organisms.[27] Most of the research done in this context focuses on insect–computer hybrid systems. Such biohybrids use the wings, muscles, or neural pathways of insects for movement and environmental interaction. By using the natural physiology of insects, this cluster aims to overcome the limitations related to size, power, or manoeuvrability of fully artificial micro-robots. For example, cyborg cockroaches equipped with sensors and wireless control units have been tested in controlled environments to navigate through obstacles, providing proof-of-concept data for search-and-rescue operations. Research in this cluster often focuses on neuromuscular stimulation for fine motor control as well as finite-state-machine–based navigation and closed-loop feedback control. This research could lead to practical applications of biohybrid robots in search and rescue operations or environmental monitoring. The Map of Science identifies Nanyang Technological University, and particularly the Hirotaka Sata Group, as the world's leading institution, both in publication output and average yearly citations.

26 Map of Science, Cluster ID: 74836, Available online: science-map.eto.tech/cluster/?version=2&cluster_id= 74836 (last accessed 28 November 2025).
27 Map of Science Cluster ID 51279, Available online: sciencemap.eto.tech/cluster/?version=2&cluster_id=51279 (last accessed 28 November 2025).

4 AI development in Singapore

Singapore's AI ambitions can only be realised when the knowledge generated by its research community is translated into real-world solutions. NAIS 2.0 supports this by building a strong local AI ecosystem that brings together academia, industry and government. These three pillars connect scientific expertise with societal priorities, business needs, and public priorities. This reflects the systemic approach of the NAIS 2.0 and encourages stakeholder participation and collaboration, which are essential in the translation of new knowledge into concrete solutions.

Accordingly, this section begins by analysing patent activity and industry involvement in the research clusters where Singapore's AI community is most active. It then outlines the key applications currently being pursued in Singapore, before concluding with an overview of the conditions shaping the nation's future AI developments.

Patenting activity and industry involvement in Singapore's AI research

The ETO's Map of Science was used to assess patent activity in the eight previously identified research clusters, as well as industry involvement in the research they produced. The dataset underpinning the Map of Science draws from the Lens's database, among the largest patent databases available, which enables the tracking of patents associated with individual research articles. This information, when aggregated, offers insights into the translational potential of the work done by each cluster. Industry involvement, on the other hand, is evaluated by examining author affiliations, which are used to classify the author-affiliated organisation as one of five types: Education, Company, Nonprofit, Government, or null (unknown). Through this, the Map of Science can assess industry involvement at the cluster level. A limitation arises because not all articles include author affiliation details. For this reason, the ETO notes that the measure of industry involvement for clusters is probably an underestimate. Patenting activity and industry involvement are evaluated using the following metrics:

- *Patent impact rating* shows how often patents cite articles in that cluster relative to other clusters. For instance, articles in a cluster with a patent impact rating of 90 are on average cited more by patents than 90% of all other clusters.
- *%-Articles* with a patent citation gives the percentage of articles within that cluster that is cited by one or more patents.
- *Patent-citation rate* provides the number of patents that cite the output of the research cluster per 100 articles.[28]
- *%-Industry affiliated* gives the percentage of articles in the cluster that involve at least one author connected to industry.[29]

28 A normalisation of the ETO-provided metric of total number of citing patents (the number of patents that cite articles within the research cluster) to compare clusters independent of their size.

29 ETO notes that many records lack information on the authors' industry connections. As a result, the %-industry affiliated is like an undercount.

Benchmarking was carried out by comparing the eight AI research clusters where Singapore is most active with other AI-focused research clusters in the same field of science. Hence, the mathematics AI research cluster in which Singapore is active was benchmarked against all mathematics AI clusters, while computer science AI clusters were benchmarked against the broader set of all computer science AI clusters. Because the clusters are automatically generated, smaller clusters may not have a coherent theme. A minimum cluster size of 50 publications was therefore used as an inclusion criterion.

First, Singapore is particularly active in the mathematics AI research cluster on nonconvex-nonconcave minimax optimisation. The articles in this cluster are cited at a lower rate, indicating lower patenting activity being generated by the work conducted in the context of this cluster. However, industry involvement in this research cluster was 72% higher than AI research clusters in mathematics.

Second, the AI research clusters in computer science where Singapore is active show no meaningful differences from the broader dataset in terms of patent impact and the share of articles with at least one patent citation. Yet, when normalised by cluster size, articles in the AI research clusters in computer science where Singapore is active are cited by patents only half as often as those in computer science research clusters overall. At the same time, industry involvement in these research clusters is 10% higher than in the overall research clusters.

The results from the benchmarking therefore indicate that Singapore's AI research activity is concentrated in clusters with relatively high industry involvement. This suggests that Singapore is effective at engaging relevant industry actors and incorporating their input. On the other hand, patenting activity in these areas is lower than the average observed across AI-focused research areas within the same field of science. This may stem from various factors; for instance, certain research areas concentrate on fundamental or doctrinal issues rather than applied innovation. Whilst it is entirely possible that such research will contribute to important AI developments over time, the resulting patenting activity is likely to appear in other research areas that apply the insights of this more fundamental or doctrinal work. Alternatively, some cutting-edge areas of research may be so novel that additional time is needed before patenting activity emerges. Future studies could provide further insights or explanations into the below-average patenting activity observed in these areas.

Application of AI Technologies

The NAIS 2.0, as noted previously, makes a distinction between different AI domains. One of these is AI for science, which refers to applications that boost research productivity across different scientific fields. Another concerns AI for business operations, which includes those applications of AI technology that stand to transform business operations and optimise their efficiency.

AI for science

Across the interviews, three general AI capabilities emerged as key for Singapore to increase future research productivity. These capabilities cut across scientific disciplines. In the formal sciences, for instance, they can support the discovery of underlying mathematical structures within datasets. Their impact is even broader in the applied natural sciences, where they enable the simulation of complex chemical reactions, the modelling of bioactivity in new medicines, the recognition of patterns in astrophysics, and the analysis of theoretical materials to predict their properties.

The first identified capability concerns AI's ability to process large datasets with greater speed and precision than humans. This allows them to identify patterns and extract insights more efficiently, ultimately enhancing research productivity across a wide range of scientific fields. For instance, researchers at Nanyang Technological University have applied machine learning both to satellite data, improving frameworks for humanitarian disaster relief, and to seismic data, producing databases that advance topographic mapping and imaging of the earth's crust.[30] Similarly, researchers from A*STAR's Genome Institute and the National University of Singapore's Yong Loo Lin School of Medicine have collaborated to use AI in analysing large datasets, streamlining the discovery and design of gene-editing enzymes.[31] Second, AI technologies can be integrated into advanced scientific simulations to enhance both their efficiency and accuracy. Such AI applications are especially relevant for fields of science that study complex interactions between different components of complex systems. Such systems generally fall into three categories: natural systems, such as those studied in ecosystem modelling; physical systems, such as those examined in materials science; and social systems, such as those applied in urban planning. In Singapore, this AI capability is broadly explored and applied across all three categories, with examples including enhanced long-term climate simulations, improved predictions of colour-coated solar panel performance, and advances in traffic management.[32] Third, AI technologies drive tools that help researchers synthesise knowledge, identify important findings, and track trends in research. These tools allow researchers to review large bodies of academic literature, verify research findings in relatively short periods of time, and improve hypothesis generation. Additionally, they make insights from one scientific field more accessible to others, encouraging interdisciplinary exchange.

AI for business operations

When asked about applications of AI in business operations, industry experts reported that current applications generally pursue four main goals: increasing automation, enhancing decision-making, improving business analytics, and boosting customer engagement. These applications are seen as creating value by enhancing both the efficiency and effectiveness of businesses. As far as adoption of AI in Singapore is concerned, the interviews highlight three sectors as leading in AI adoption: financial services, healthcare, and public service. Although adoption is occasionally driven by hype or marketing considerations, organisations typically hope to leverage AI to improve the efficiency and effectiveness of their work.

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30 Anirudh Rao, Jungkyo Jung, Vitor Silva, Giuseppe Molinario and Sang-Ho Yun, 'Earthquake building damage detection based on synthetic-aperture-radar imagery and machine learning' (2023) 23 Natural Hazards and Earth System Sciences 789, Wen Ding, Tianjue Li, Xu Yang, Kui Ren and Ping Tong, 'Deep neural networks for creating reliable PmP database with a case study in southern California' (2022) 127 (4) Journal of Geophysical Research: Solid Earth 1.

31 See for example Chia BS Shao, Samantha Y Fen Seah, Bolun Wang, Kimberle Shen, Diya Srivastava and Wei Leong Chew, 'Engineering a New Generation of Gene Editors: Integrating Synthetic Biology and AI Innovations' (2025) 14(3) ACS Synthetic Biology 636.

32 Chengxin Wang and Gary Tan, 'Spatio-Temporal Forecasting for Traffic Simulation Framework' IEEE/ACM 27th International Symposium on Distributed Simulation and Real Time Applications (DS-RT) (Singapore 2023) 109; Xin Wang et al, 'CondensNet: Enabling Stable Long-Term Climate Simulations via Hybrid Deep Learning Models with Adaptive Physical Constraints' (2025), available online: https://arxiv.org/abs/2502.13185 (last accessed 28 November 2025); Min Hsian Saw, Mauro Pravettoni and Erik Birgersson, 'STC Short-Circuit Current Prediction and I–V Simulation of Colored BIPV Modules With Machine Learning and One-Diode Equivalent Circuit Models' (2022) 12(6) IEEE Journal of Photovoltaics 1533.

Financial services

The financial services sector employs AI for a broad range of purposes, including back-end automation, customer service, risk management, and fraud detection. They support tasks ranging from credit and fraud risk prediction to the detection of financial crime and the analysis of unstructured data. For example, OCBC Bank has applied machine learning to credit card fraud detection since 2022. More recently, it announced a partnership with Singapore Management University to develop quantum machine-learning approaches capable of analysing complex, unstructured data to reveal patterns and anomalies associated with fraud.[33] The Monetary Authority of Singapore supports such initiatives through its Artificial Intelligence Programme in Finance. Launched at the 2021 Singapore FinTech Festival under this programme, the NovA! Consortium aims to provide the financial services sector with AI-driven sustainability insights to support more effective decision-making. To this end, it develops AI-powered applications that support environmental, social, and governance (ESG) risk assessments for the origination, underwriting, and servicing of sustainability-linked loans. Currently, 16 consortium members have joined the initiative, including Aicadium, Bank of China, Citi Singapore, and DBS Bank.

Healthcare

The primary uses of AI in healthcare are found in diagnostics, patient care, and hospital operations. Notable applications include systems that detect eye disease from retinal images, predict kidney failure from kidney scans, and estimate the probability of patient readmission or short-term emergency department use. As a central driver of AI adoption in healthcare, the government recently announced plans to integrate national health records, socio-economic and genetic data to strengthen AI-powered preventative care. As a first step, the national HealthHub app, which holds Singapore citizens' health records, will be merged with the apps from Singapore's three healthcare clusters. This integration will allow Singaporeans to access personalised healthcare information.[34]

These innovations are made possible through close collaboration between healthcare providers and research institutions. One example is SELENA+, a deep-learning system for detecting serious eye conditions, jointly developed by the Singapore National Eye Centre, the Singapore Eye Research Institute, and the National University of Singapore Institute of Computing. This deep-learning system is used to analyse retinal images to identify early indicators of diabetic retinopathy, glaucoma, and age-related macular degeneration.[35] Although such systems offer significant benefits, the application of AI in healthcare must address critical issues, including privacy risks, ethical challenges, the necessity of human oversight, and the high level of explainability required for diagnostic AI tools.

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33 Benjamin Liu, OCBC to develop quantum applications with NUS, NTU, SMU (18 July 2025) https://news.smu.edu.sg/sites/news.smu.edu.sg/files/smu/news_room/20250718_BT_p12_OCBC%20to%20develop%20quantum%20applications%20with%20NUS%2C%20NTU%2C%20SMU.pdf (last accessed 28 November 2025).

34 Ong Ye Kung, 'Speech by Mr Ong Ye Kung, Minister for Health at the Synapxe AI Accelerate Conference on 16 June 2025' (Ministry of Health, 16 June 2025), no 16-17 available online: https://www.moh.gov.sg/newsroom/speech-by-mr-ong-ye-kung--minister-for-health-at-the-synapxe-ai-accelerate-conference-on-16-june-2025 pdf (last accessed 28 November 2025).

35 David Chuen Soong Wong, Grace Kiew, Sohee Jeon & Daniel Ting, 'Singapore Eye Lesions Analyzer (SELENA): The Deep Learning System for Retinal Diseases' in Andrzej Grzybowski (ed), Artificial Intelligence in Ophthalmology (Springer, Cham 2021) 177–185.

Public services

Singapore's government has been at the forefront of adopting AI in the public sector, both to improve the efficiency of government services and to inspire broader public confidence in the technology. It applies AI technologies in areas such as citizen service automation, public housing, public transport, infrastructure management, and security. Specific uses include improving job search and matching, predictive maintenance of public housing, enhanced security checks at border control checkpoints, and better responses to service disruptions. At the same time, public sector applications must carefully address ethical concerns, data governance, and potential biases. By balancing these considerations with public interests, Singapore's government seeks to maintain public trust while encouraging general adoption of AI technology across society.

Conditions shaping future AI adoption

The interviewed industry experts described Singapore's large enterprises as generally up-to-date on AI developments, relatively skilled and open to experimentation. Additionally, Singapore's governance environment (for more on this see section 5b below) is mentioned frequently as a factor that inspires confidence and provides the certainty required for experimentation. Lastly, the interview accounts highlight the high concentration of specific technical expertise present in Singapore as a critical enabler in helping businesses achieve their AI ambitions. While participants generally expressed a positive view of enterprise AI adoption in Singapore, one participant emphasised that AI technology requires suitable use cases to leverage its full potential. Currently, enterprise applications tend to be limited to specific tasks, primarily using generative AI for purposes such as summarisation, writing support, and template prefilling. These tools were described as 'solutions that offer incremental productivity gains, while the lack of a clear and suitable use case limits the broader impact of the technology and its potential for significant efficiency gains.'

Across the interviews, participants agreed that narrow, purpose-built AI applications have greater potential for impact and efficiency gains. Because these solutions are specifically tailored, they can be integrated more easily into existing workflows. Nevertheless, Industry experts agreed that such integration remains a challenge for large enterprises. This was described by one expert as: 'to fully unlock the potential of such applications, their implementation must be carefully aligned with the operational processes within which they will be used. This requires a business case that fits with the application, a significant degree of customisation, and specific skills.' In practice, most organisations tend to underestimate the effort and investment this requires. Interviewees generally framed the industry's challenges in implementing tailored AI applications as stemming from ambitions driven more by marketing or hype than by genuine value creation. For example, this was described as 'organisations are not clear on why they want to use a certain technology. They want to use the technology and look for a problem to solve, whilst it should be the other way around: we should start with a problem and find the appropriate technology.'

From the interviews, four conditions emerged that shape future AI adoption in Singapore: the speed of SME adoption, the challenges of integrating new technologies in existing IT environments, resource availability, and the localisation of AI.

AI adoption by SMEs

Large enterprises are currently driving much of the progress in AI adoption in Singapore, with uptake rising from 16,7% to 62,5% from 2018 to 2024.[36] In contrast, SMEs, accounted for 99% of Singapore's enterprises, contributed 44% of nominal value added, and employed 71% of the workforce in 2023, remain slow to adopt.[37] Their adoption rate increased only slightly from 3,5% in 2018 to 4,2% in 2023.[38] However, Singapore's latest Digital Economy Report shows a sharp rise in AI adoption among SMEs, climbing from 4,2% to 14,5% in 2024.[39] Several participants noted that while SMEs are generally aware of AI, they feel little urgency and do not view adoption as necessary. Their adoption is further constrained by the difficulty of acquiring the technical expertise and specialised skills required to successfully implement AI solutions.

AI adoption by non-SMEs

Although large enterprises are leading in AI adoption, they encounter challenges that are distinct from those faced by SMEs. One central challenge is the integration of AI with their legacy IT systems, which often complicates both interoperability and full-scale deployment. This challenge is further compounded by the fact that AI is a relatively immature technology, making it difficult for organisations to anticipate associated risks. Consequently, these enterprises must not only overcome technical barriers but also adapt their broader business processes and maintain compliance in the face of evolving technologies.

Resource availability

Training and fine-tuning AI models require vast amounts of high-quality data as well as significant compute. These demands are widely recognised as global barriers to AI development, but are particularly pronounced in Singapore.[40] The country's relatively small market size limits the volume of data that can be produced locally, while its limited land area and high population density inherently restrict its capacity to build local data centres.

While limited data availability affects AI developments at large, its effects diverge across industries. Sectors such as finance, for instance, generally require highly specialised and domain-specific datasets. Yet privacy regulations, finance-specific regulatory requirements, and fragmented international frameworks on cross-border data flows make such data difficult to obtain or share. Even though the financial services sector is one of the leading sectors when it comes to AI adoption, the lack of sufficient, high-quality data remains a bottleneck.

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36 Infocomm Media Development Authority (IMDA), Singapore Digital Economy Report 2025 (2025) p 14, www.imda.gov.sg/-/media/imda/files/about/resources/corporate-publications/annual-report/imda-sgde-report-fy2024-2025.pdf (last accessed 28 November 2025); Infocomm Media Development Authority (IMDA), Singapore Digital Economy Report 2024 (SGDE) (2024) p 4, https://www.imda.gov.sg/-/media/imda/files/infocomm-media-landscape/research-and-statistics/sgde-report/singapore-digital-economy-report-2024.pdf (last accessed 28 November 2025).

37 Department of Statistics Singapore, Topline Estimates for All Enterprises and SMEs, available via: tablebuilder.singstat.gov.sg (last accessed 28 November 2025).

38 Infocomm Media Development Authority (IMDA), Singapore Digital Economy Report 2025 (SGDE) (2025) p 14, www.imda.gov.sg/-/media/imda/files/about/resources/corporate-publications/annual-report/imda-sgde-report-fy2024-2025.pdf (last accessed 28 November 2025).

39 Infocomm Media Development Authority (IMDA), Singapore Digital Economy Report 2025 (SGDE) (2025) p 14, www.imda.gov.sg/-/media/imda/files/about/resources/corporate-publications/annual-report/imda-sgde-report-fy2024-2025.pdf (last accessed 28 November 2025).

40 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 47-63, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025).

Finally, beyond restrictions in data availability, Singapore faces infrastructural limitations in access to compute. Compared to industry leaders such as the United States and China, Singapore's AI ecosystem has limited access to the compute resources needed to train and fine-tune models at scale. This creates a competitive disadvantage for both researchers and developers, thereby negatively affecting the overall growth of the local AI ecosystem.

Localisation

For AI technologies to inspire confidence and achieve widespread adoption, they must reflect the context in which they are used. This is done through localisation: adapting AI to the cultural, linguistic, economic, infrastructural, environmental, and regulatory context in which it operates to ensure that technology provides relevant, accurate, and trustworthy output.[41] Interviewees consistently reported that AI localisation is a central priority in Singapore's AI ecosystem. The country's diverse cultural and linguistic makeup, unique economic and political environment, and small population limit the availability of locally representative datasets needed to ensure that AI applications reflect Singapore's local context. Singapore's national identity is a fundamental concern in this respect, but the importance of local relevance goes beyond this: text-to-speech engines should understand Singlish, financial-sector chatbots must comply with Singapore law, AI-enabled disease-prediction tools need to incorporate relevant demographic and environmental factors, and AI tools used in a legal context must align with Singapore's unique legal system. Moreover, localised AI is also vital in scientific research. For example, population-specific drug responses must be taken into account when developing new medicines, and local data is essential for training AI models to accurately predict weather patterns.[42]

Data that is both high-quality and relevant to Singapore's local context is often scarce. Even when available, adapting general-purpose models to a specific local context requires specialised expertise and might require substantial compute, both in short supply. Moreover, many localisation methods remain resource-intensive and expensive. To address these challenges, AI Singapore, A*STAR, and IMDA launched the National Multimodal Large Language Model Programme. Under this programme, AI Singapore developed SEA-LION, an open-source family of large language models built for Southeast Asia's diverse contexts, languages, and cultures. By training on Southeast Asian languages such as Thai, Vietnamese, Bahasa Indonesia, SEA-LION achieves better representation and alignment to the Southeast Asian context than models based on Western or Chinese data.[43] AI Singapore first released SEA-LION in 2023

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41 Infocomm Media Development Authority (IMDA) and Personal Data Protection Commission (PDPC), Model Artificial Intelligence Governance Framework, 2nd Edn (2020) no 3.10 available online: https://www.pdpc.gov.sg/-/media/Files/PDPC/PDF-Files/Resource-for-Organisation/AI/SGModelAIGovFramework2.pdf (last accessed 28 November 2025) and Dignata Das and Berwyn Kwek, 'AI and data-driven urbanism: The Singapore experience' (2024) 7 Digital Geography and Society 1. Note that AI systems tend to reflect Western-centric norms and values, see Shayne Longpre et al, 'A Large-Scale Audit of Dataset Licensing and Attribution in AI' (2024) 6 Nature Machine Intelligence 975, 979-980 and Yan Tao, Olga Viberg, Ryan S Baker, and René F Kizilcec, 'Cultural Bias and Cultural Alignment of Large Language Models' (2024) 3 PNAS Nexus 346.

42 See for example Gustau Camps-Valls et al, 'Artificial Intelligence for Modeling and Understanding Extreme Weather and Climate Events' (2025) 16 Nature Communications 1919.

43 Lionel Koh, Jirat Boomuang, Pyn Lim and Francis Wang, Mitigating Bias, 'Ensuring Fairness: SEA-LION's Strategies for Inclusive LLM in a Diverse Region' (2025) no 3.1, available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5128914 (last accessed 28 November 2025); see also Noor E and Kanitroj B, Speaking in Code: Contextualizing Large Language Models in Southeast Asia (Carnegie Endowment for International Peace, January 2025) available online: https://carnegie-production-assets.s3.amazonaws.com/static/files/Noor_LLMs_final.pdf (last accessed 28 November 2025).

and has since collaborated with IBM and Sony Research on its improvement.[44] These efforts ultimately resulted in the release of SEA-LION v4 in 2025, the fifth iteration of the model.[45] Moreover, the project is generating regional momentum, with models being adopted to create versions specifically tailored to local languages. Examples include WanChanLion, a SEA-LION-based model for Thai, and Sahabat-AI, a collection of SEA-LION models developed for Bahasa Indonesia, Javanese, and Sundanese.[46]

Moreover, the interviewed industry experts reported a shift from general open-ended AI models towards narrow, purpose-built AI applications. These tools have a well-defined scope and purpose, which makes them easier and more cost-effective to adapt to local contexts. Combined with advancements arising from initiatives such as SEA-LION, this shift is anticipated to reduce the practical limitations of limited local data. Moreover, several interviewees noted that improvements in localisation techniques, combined with more efficient training and fine-tuning methods, are expected to reduce costs of developing locally relevant AI tools, thereby making trustworthy and Singapore-specific AI increasingly viable.

5 AI governance in Singapore

Singapore balances the potential benefits of AI with a strong awareness of risk. Throughout the interviews this risk awareness was frequently cited as the reason for the nation positioning itself as an early adopter rather than a first adopter. As one participant put it: 'Singapore does not want to be an initial adopter, but rather an early mover. AI adoption is not done because AI exploded, but rather because it offers true value.' This results in what has been described as a careful yet ambitious approach to AI ecosystem development, risk management, and AI governance as well as an AI community that is generally aware of the potential risks and harms. Several participants characterised Singapore's approach to AI risk management as 'rational and pragmatic.' When asked to clarify what makes the nation's approach to AI risk management 'rational and pragmatic', participants generally referred to two aspects. First, Singapore's AI risk management approach is characterised by a long-term vision that aligns with the broader AI ecosystem development strategy. As such, it fits with the Smart Nation initiative and is consistent with Singapore's ongoing digital transformation.[47] Combined with Singapore's stable political environment, this vision enables the formulation of clear, long-term goals. Second, Singapore's broader process for formulating its AI vision and goals reflects the same pragmatic and rational approach. This process is marked by close consultation with experts, including national

44 Raymond Ng et al, 'SEA-LION: Southeast Asian Languages in One Network' (2025) available online: https://arxiv.org/pdf/2504.05747 (last accessed 28 November 2025); Sony Research, 'Sony Research and AI Singapore Sign MOU to Conduct Collaborative Research on Large Language Models for Southeast Asian Languages' (10 September 2024) available online: https://research.sony/news-events/240910 (last accessed 28 November 2025).

45 AI Singapore, aisingapore/sealion (GitHub repository) available online: https://github.com/aisingapore/sealion (last accessed 28 November 2025).

46 SEA-LION, 'Deployment & Successes' (SEA-LION) available online: https://sea-lion.ai/deployment-successes-2 (last accessed 28 November 2025); AI Singapore and VISTEC, WangchanLion (GitHub repository) available online: https://github.com/vistec-AI/WangchanLion (last accessed 28 November 2025); GoToCompany, Llama-Sahabat-AI-v2-70B-IT (Hugging Face repository) available online: https://huggingface.co/GoToCompany/Llama-Sahabat-AI-v2-70B-IT (last accessed 28 November 2025).

47 This can be traced back to the 1981 National Computer Board, see Ezra Ho, 'Smart Subjects for a Smart Nation? Governing (Smart) Mentalities in Singapore' (2017) 54 Urban Studies 3101, 3107.

and international researchers as well as industry stakeholders.[48] Accordingly, this process relies on stakeholder participation in defining governance objectives and identifying AI risks. One participant emphasised that Singapore 'attempts to work with all stakeholders and tries to create a holistic view: 'governments alone do not have all the answers.' Subsection 2a illustrates the challenges Singapore faces in managing AI risks, while subsection 2b outlines the overarching strategy it employs to govern the technology and mitigate these risks.

Translating principles to governance

Transparency, explainability, fairness and human-centricity form the four fundamental principles that underpin Singapore's AI governance environment.[49] These foundational principles derive from the overarching goal of Singapore's National AI Strategy 2.0: to leverage AI for the public good requires the technology to be transparent, explainable, fair and safe. The general-purpose nature of AI technologies, combined with the nation's particular economic and political context, has shaped Singapore's distinctive approach to AI governance.

Singapore's National AI Strategy recognises AI as a general-purpose technology.[50] Such technologies are characterised by their:[51]

- Pervasiveness: they can be applied across a wide range of sectors rather than being limited to a single industry.
- Inherent potential for technological improvements: they evolve over time as they spread through the economy, generating broader productivity gains.
- Innovational complementarities: acting as 'enabling technologies', they create new opportunities and transform other technologies and processes rather than offering standalone solutions.

From the interviews, three factors emerged that complicate Singapore's efforts to develop a clear and effective AI governance strategy. Two factors stem from the general-purpose nature of the technology, while the third arises from Singapore's unique economic and political context. First, AI's pervasiveness allows it to be applied broadly across domains for different purposes. As a result, the risks posed by the technology manifest differently depending on the context in which it is used, making AI-risks broad and sector-specific. Second, AI's inherent potential for technological improvements drives rapid and continual evolution, with AI risks evolving in parallel. This makes such risks dynamic and difficult to anticipate, with the potential for new and unforeseen risks to emerge. The final factor arises not from the

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48 Philip Frana, 'Assessing Smart Nation Singapore as an International Model as an International Model for AI Responsibility' (2024) 7(1) Artificial Intelligence and responsibility 8.

49 Infocomm Media Development Authority (IMDA) and Personal Data Protection Commission (PDPC), Model Artificial Intelligence Governance Framework, 2nd Edn (2020) no 2.7, available online: https://www.pdpc.gov.sg/-/media/Files/PDPC/PDF-Files/Resource-for-Organisation/AI/SGModelAIGovFramework2.pdf (last accessed 28 November 2025).

50 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 5, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025).

51 Timothy Bresnahan and Manuel Trajtenberg, 'General purpose technologies "Engines of growth"?' (1995) 65 Journal of Econometrics 83.

nature of the technology, but rather from Singapore's economic and political environment.[52] Shaped by the nation's history, this environment has long been recognised as business-friendly and pro-innovation. Since gaining independence in 1965, Singapore has outpaced most developing and industrialising nations in economic growth by maintaining macroeconomic stability and adopting liberal trade and investment policies. This created an environment that ensured minimal trade distortions and encouraged investment, thereby creating sustained long-term growth.[53] As a result, Singapore's tradition of business-oriented policies and institutions has created a business-friendly and pro-innovation environment for its national AI ecosystem.[54] Maintaining this successful business-friendly and pro-innovation environment, whilst managing novel AI risks, therefore shapes Singapore's approach to AI governance.

This approach is further influenced by the specific AI risks that are prioritised. For Singapore, two AI-specific risks are of particular concern. The first risk relates to the use of AI to spread misinformation and disinformation, particularly in the context of Singapore's democratic processes.[55] AI-generated deepfakes, for example, can be used to influence election outcomes and erode public confidence in democratic institutions. Second, a key concern is the potential use of AI to expand the scale and effectiveness of scams and cyberattacks.[56] The use of AI technologies in this manner presents significant risks to social cohesion as well as national security.[57]

Singapore's approach to AI governance

In managing these risks, Singapore attempts to strike a balance between 'letting innovation happen and identifying, evaluating and proactively managing the risks that arise'.[58] Singapore's AI governance initiatives, on the one hand, aim to mitigate risks in order to inspire confidence in the technology and build broad public support. On the other hand, they are designed to maintain Singapore's pro-innovation and business-friendly environment.[59] This balancing act has shaped Singapore's unique approach to AI

52 Poh Kam Wong and Annette Singh, 'From Technology Adopter to Innovator: Singapore' in Björn Johnson and Ashish Arora (eds), Small Country Innovation Systems (Edward Elgar Publishing 2008) p 93-94.

53 Rachel van Elkan , 'Singapore's Development Strategy' in Kenneth Bercuson(ed), Singapore: A Case Study in Rapid Development (International Monetary Fund 1995) p 15; Linda Lim, 'Fifty Years of Development in the Singapore Economy: An Introductory Review' (2015) 60(3) Singapore Economic Review 1.

54 Jason Grant Allen, Jane Loo and Jose Luna, 'Governing Intelligence: Singapore's Evolving AI Governance Framework' (2025) 1 Cambridge Forum on AI: Law and Governance 6; Shaleen Khanal, Hongzhou Zhang and Araz Taeihagh, 'Building an AI Ecosystem in a Small Nation: Lessons from Singapore's Journey to the Forefront of AI' (2024) 11 Humanities and Social Sciences Communications 866.

55 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 55, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025).

56 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 55, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025).

57 Blessing Guembe, Ambrose Azeta, Sanjay Misra, Victor Chukwudi Osamor, Luis Fernandez-Sanz and Vera Pospelova, 'The Emerging Threat of AI-driven Cyber Attacks: A Review' (2022) 36(1) Applied Artificial Intelligence; Jingru Yu, Yi Yu, Xuhong Wang, Yilun Lin, Manzhi Yang, Yu Qiao and Fei-Yue Wang, 'The Shadow of Fraud: The Emerging Danger of AI-powered Social Engineering and its Possible Cure' (2024) available online: https://arxiv.org/abs/2407.15912 (last accessed 28 November 2025).

58 Nydia Remolina Leon, 'How to address the AI Governance discussion? What can Singapore do?' (2019) SMU Centre for AI & Data Governance Research Paper, no. 03, p 5.

59 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 11, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025); Infocomm Media Development Authority (IMDA) and Personal Data Protection Commission (PDPC), Model Artificial Intelligence Governance Framework, 2nd Edn (2020) p 8 , available online: https://www.pdpc.gov.sg/-/media/Files/PDPC/PDF-Files/Resource-for-Organisation/AI/SGModelAIGovFramework2.pdf (last accessed 28 November 2025); Jason Grant Allen and Jane Loo, 'Singapore's Evolving AI Governance Framework' in Mimi Zou, Cristina Poncibò, Martin Ebers, and Ryan Calo (eds), The Cambridge Handbook of Generative AI and the Law (Cambridge University Press 2025) p 160.

governance, characterised by its soft-law approach,[60] consultation-focused multistakeholder governance model,[61] and a tiered sector-specific focus.[62]

Soft-law approach

Several participants highlighted that Singapore's soft law approach is driven by the general-purpose nature of AI technologies. Unlike 'hard law', soft law instruments do not impose binding obligations on companies or individuals but rather offer guidelines, voluntary codes, or recommended practices. Singapore's approach to AI governance is therefore defined by 'nonbinding norms and techniques that create substantive expectations that are not directly enforceable' such as those found in, for example, Singapore's Model AI Governance Framework.[63]

Despite this soft law approach, Singapore's AI technologies do not exist in a legal vacuum. Existing general legal frameworks serve as primary mechanisms to ensure responsibility and accountability of both individuals and organisations that use AI.[64] However, AI developments must be closely monitored to identify potential new risks and to continuously evaluate whether existing frameworks sufficiently address such risks. This is done through Singapore's multistakeholder governance model.

Multistakeholder governance

Stakeholder consultations and industry collaborations play an important role in monitoring emergent risks and evaluating existing regulatory frameworks. This collaborative focus in AI governance was a recurring theme in the interviews, as one participant explained: 'it is through these cooperations that relevant information is exchanged and mutual guidance is provided.' Singapore's governance frameworks, created through its multistakeholder governance model, are generally regarded as successful and recognised for their flexibility.[65] Examples of these frameworks include the Model AI Governance Framework (second edition), developed in consultation with organisations such as Accenture, Apple, Facebook, Google, Grab, IBM, OCBC, PwC, Singtel, and Temasek. Similarly, the Model AI Governance Framework for Generative AI was created with input from companies including Adobe, Cisco, EY, Microsoft, NCS, SAP, and Visa. The interviewed experts consistently reported that these governance

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60 Jason Grant Allen and Jane Loo, 'Singapore's Evolving AI Governance Framework' in Mimi Zou, Cristina Poncibò, Martin Ebers, and Ryan Calo (eds), The Cambridge Handbook of Generative AI and the Law (Cambridge University Press 2025) p 154; Araz Taeihagh, 'Governance of Artificial Intelligence' (2021) 40(2) Policy and Society 137, 146-147.

61 Jian Xu, Terence Lee and Gerard Goggin, 'AI Governance in Asia: Policies, Praxis and Approaches' (2024) 10(3) Communication Research and Practice 275, 280.

62 Jason Grant Allen and Jane Loo, 'Singapore's Evolving AI Governance Framework' in Mimi Zou, Cristina Poncibò, Martin Ebers, and Ryan Calo (eds), The Cambridge Handbook of Generative AI and the Law (Cambridge University Press 2025) p 158.

63 Araz Taeihagh, 'Governance of Artificial Intelligence' (2021) 40(2) Policy and Society 137, 145. Infocomm Media Development Authority (IMDA) and Personal Data Protection Commission (PDPC), Model Artificial Intelligence Governance Framework, 2nd Edn (2020) no 1.2 and 2.2-2.3 available online: https://www.pdpc.gov.sg/-/media/Files/PDPC/PDF-Files/Resource-for-Organisation/AI/SGModelAIGovFramework2.pdf (last accessed 28 November 2025); Jason Grant Allen and Jane Loo, 'Singapore's Evolving AI Governance Framework' in Mimi Zou, Cristina Poncibò, Martin Ebers, and Ryan Calo (eds), The Cambridge Handbook of Generative AI and the Law (Cambridge University Press 2025) p 159; Infocomm Media Development Authority and AI Verify Foundation, Model AI Governance Framework for Generative AI (May 2024) p 11, available online: https://aiverifyfoundation.sg/wp-content/uploads/2024/05/Model-AI-Governance-Framework-for-Generative-AI-May-2024-1-1.pdf pdf (last accessed 28 November 2025).

64 Simon Chesterman, We, the Robots? Regulating Artificial Intelligence and the Limits of the Law (Cambridge University Press 2021), pp 88 ff.

65 Jason Grant Allen, Jane Loo and Jose Luna, 'Governing Intelligence: Singapore's Evolving AI Governance Framework' (2025) 1 Cambridge Forum on AI: Law and Governance 6; Shaleen Khanal, Hongzhou Zhang and Araz Taeihagh, 'Building an AI Ecosystem in a Small Nation: Lessons from Singapore's Journey to the Forefront of AI' (2024) 11 Humanities and Social Sciences Communications 866.

frameworks provide guidance and serve as guardrails, while close public-private cooperations serve as channels for obtaining additional information or clarification when necessary. For the government, on the other hand, information acquired through these collaborations and consultations provides opportunities to anticipate potential AI-related obstacles and risks. Additionally, these activities provide practice-informed perspectives on how such obstacles or risks might be addressed. Once specific risks, obstacles, or questions are identified, targeted initiatives can be pursued to explore these further.[66]

Tiered sector-specific focus

The National AI Strategy states that interventions should be 'risk-based, tiered, and adapted for specific vertical sectors and horizontal applications'.[67] As such, Singapore recognises two types of AI risks. First, horizontal risks arise from the technology itself and have broad cross-sectoral effects. This includes, for example, the risk of biases in AI systems. Such biases generate significant risks regardless of the context in which the technology is used; whether the technology is used to automate hiring processes, to determine credit scores in financial services, or to support diagnoses in healthcare, the potential societal harms are severe. Second, vertical risks arise from the context in which the technology is applied, creating sector-specific effects. For instance, when a financial services provider deploys an AI chatbot, it must comply with applicable financial regulations.[68] In Singapore, this means banks and payment institutions cannot use chatbots to promote cryptocurrency trading. The risk of an AI chatbot doing so is therefore specific to the financial sector. This sector-specificity has created a two-tiered system of supervision.

Supervising horizontal risks

Government bodies such as the MDDI's National AI Group, the IMDA, and the PDPC are responsible for monitoring horizontal (i.e. cross-sectoral) risks. These institutions have a broad mandate and are therefore well positioned to identify and analyse these cross-sectoral risks. Such risks are identified and analysed through multistakeholder collaborations and consultations, after which the relevant regulatory context is analysed. This analysis includes a risk assessment, which might trigger follow-up measures. While Singapore has never explicitly ruled out the option of enacting AI-specific 'hard' laws, its follow-up measures to date have been consistent with its soft-law approach. However, the government has shown itself willing to intervene in a technology-neutral manner if severe risks arise in specific contexts. For example, the Elections (Integrity of Online Advertising) Bill (Amendment) was enacted to prevent misinformation and disinformation affecting electoral processes, and explicitly mentions the use of AI tools to generate deepfake images as falling within its scope.[69]

66 A recent example relates to questions on the performance of AI in different linguistic and cultural contexts and the extent to which locally relevant guardrails hold up in these contexts. The Infocomm media Development Authority (IMDA) organised the Singapore AI Safety Red Teaming Challenge to address these questions and create a deeper understanding of the way in which AI models perform with regard to different languages and cultures in the Asia Pacific region, see Infocomm Media Development Authority, 'Singapore AI Safety Red Teaming Challenge Evaluation Report' (February 2025) available online: https://www.imda.gov.sg/-/media/imda/files/about/emerging-tech-and-research/artificial-intelligence/singapore-ai-safety-red-teaming-challenge-evaluation-report.pdf (last accessed 28 November 2025).

67 National AI Strategy: AI for the Public Good, for Singapore and the World, Smart Nation Singapore (December 2023) p 56, available online: https://file.go.gov.sg/nais2023.pdf (last accessed 28 November 2025).

68 Monetary Authority of Singapore, Guidelines on Provision of Digital Payment Token Services to the Public (Monetary Authority of Singapore 2022), available online https://www.mas.gov.sg/-/media/mas-media-library/regulation/guidelines/ps0/ps-g02-guidelines-on-provision-of-digital-payment-token-services-to-the-public/guidelines-on-provision-of-digital-payment-token-services-to-the-public-ps-g02.pdf (last accessed 28 November 2025).

69 See illustrations to section 42LA and 61MA in Elections (Integrity of Online Advertising) (Amendment) Bill 2024 (Singapore).

Supervising vertical risks

Inherent differences across sectors lead to industry-specific AI applications, which in turn generate risks unique to each sector. Singapore has designated sectoral regulators to monitor these vertical risks. For example, the Monetary Authority of Singapore serves as the regulator responsible for AI governance in the financial sector, whereas the Ministry of Health assumes this role for the healthcare sector. This process mirrors the approach to cross-sectoral risks, albeit in a more focussed manner: sectoral regulators monitor, identify, and analyse risks within their domains and assess the impact on their respective regulatory frameworks. Through their monitoring efforts, sectoral regulators identify and analyse risks within their domains and assess the impact of AI technologies on their respective sectors. Such activities by sectoral regulators have resulted in multiple sectoral soft-law initiatives. Examples include the Monetary Authority of Singapore's Veritas initiative, which developed a framework for the responsible use of AI in financial services along with the FEAT (fairness, ethics, accountability, and transparency) assessment methodology, as well as the Ministry of Health's Artificial Intelligence in Healthcare Guidelines.[70] However, while the activities of sectoral regulators mirror the broader, horizontally oriented work of institutions addressing cross-sectoral risks, their scope is more focused and the scale of their effects varies with the level of AI adoption and activity in each sector.

Singapore's and the European Union's approach compared

The European Union's AI framework centres on the AI Act, which seeks to ensure safe, trustworthy, and human-centric AI development and deployment.[71] Whilst in broad terms this mirrors Singapore's aim of leveraging AI for the public good, the European Union's approach differs in terms of structure and method. Whereas Singapore's approach is characterised by its voluntary nature and strong collaborative elements, the European Union pursues a binding regulatory regime that is primarily driven by top-down rulemaking.[72]

Soft law vs hard law

Singapore's soft law approach creates a flexible and responsive governance context in which guidelines can be updated rapidly and tested in regulatory sandboxes under the guidance of its sectoral regulators. By leveraging consistent multi-stakeholder consultations, this method therefore creates an adaptable regulatory environment that can evolve in tandem with technological advancements. In contrast, the European Union's AI Act establishes a single, uniform governance framework through centralised rulemaking. While national institutions, industry stakeholders, and civil society are involved in its implementation, the act itself is created through a top-down process. This approach aligns with the purpose of the AI Act: creating a single comprehensive framework requires a uniform system.[73]

70 Monetary Authority of Singapore, Veritas Document 3 – FEAT Principles Assessment Methodology (Monetary Authority of Singapore 2022), available online: https://www.mas.gov.sg/-/media/mas-media-library/news/media-releases/2022/veritas-document-3---feat-principles-assessment-methodology.pdf (last accessed 28 November 2025); Ministry of Health, Artificial Intelligence in Healthcare Guidelines (AIHGle) (Ministry of Health 2021), available online: https://isomer-user-content.by.gov.sg/3/9c0db09d-104c-48af-87c9-17e01695c67c/1-0-artificial-in-healthcare-guidelines-(aihgle)_publishedoct21.pdf (last accessed 28 November 2025).

71 Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) [2024] OJ L1689/1, recital (6).

72 Marta Gamito and Christopher Marsden, 'Artificial Intelligence Co-regulation? The Role of Standards in the EU AI Act' (2024) 32(1) International Journal of Law and Information Technology; Ugo Pagallo, 'Why the AI Act Won't Trigger a Brussels Effect' in AI Approaches to the Complexity of Legal Systems (Springer, forthcoming) available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4696148 (last accessed 28 November 2025).

73 Celso Cancela-Outeda, 'The EU's AI Act: A Framework for Collaborative Governance' (2024) 4 AI & Ethics 1, 4-6.

In Europe's multi-level and highly diverse context, such a uniform system can only be established through a top-down approach. Relative to Singapore's model, this creates relatively inflexible regime, which may struggle to keep up with rapid technological developments.

Collaborative governance vs top-down regulation

Through its collaborative approach, Singapore is able to leverage the expertise of industry stakeholders in developing its AI governance frameworks. Additionally, through these collaborations sectoral insights can be incorporated in these frameworks, which enhances the sector-specific relevance of Singapore's AI governance approach. However, such collaborative governance models are criticised for providing industry stakeholders with the greatest ability to shape the regulatory context, whilst they have the least interest in regulation.[74] In contrast, the European Union takes a rights-focused approach in the AI Act, aiming to ensure a high level of protection of health, safety, and fundamental rights.[75] This has resulted in a top-down regulatory model rather than Singapore's collaborative model. This approach grounds governance frameworks in public values, thereby helping to build public trust. However, imposing regulations through a top-down model provides no guarantees that organisations internalise those regulations. These models require bottom-up elements in their implementation, as well as strong enforcement mechanisms.

Sector-specific approach vs risk-based approach

Singapore's sector-specific approach to AI governance enables the creation of standards that are context-sensitive and highly detailed. Moreover, the multi-stakeholder consultative processes supporting this approach enable it to tap into industry expertise and create tailored frameworks that address serious risks without affecting other sectors. The European Union's AI Act, by contrast, prioritises regulatory uniformity rather than sector specificity. Instead of differentiating between vertical AI risks, it seeks to establish a common standard of protection through a risk-based model that aligns with the EU's rights-focused, value-driven approach.[76] At its heart is a four-tiered model that classifies AI systems according to the level of risk they pose to health, safety, and fundamental rights. This model distinguishes between unacceptable risk, high risk, limited risk, and minimal risk.[77] The European approach therefore combines a risk-based model with a tiered system of requirements and obligations, providing a proportionate set of legal obligations at each risk level. Yet, its pursuit of creating an EU-wide AI governance framework has produced broad risk categories, which complicate the effective recognition of sectoral differences and sector-specific risks. Singapore, on the other hand, has avoided this challenge by involving industry stakeholders to incorporate industry insights in their governance processes, thereby enabling sector-specific solutions and greater adaptability in its governance frameworks.

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74 Simon Chesterman, 'The Tragedy of AI Governance' in Sven Nyholm, Atoosa Kasirzadeh, John Zerilli (eds) Contemporary Debates in the Ethics of Artificial Intelligence (Wiley 2025) (forthcoming).

75 Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) [2024] OJ L1689/1, recital (7).

76 See for example Isabel Kusche, 'Possible Harms of Artificial Intelligence and the EU AI Act' (2024) 30 Journal of European Public Policy 1.

77 Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) [2024] OJ L1689/1, recital (26)-(27).

6 Conclusion

AI technologies are a strategic national priority for Singapore, enabling the small island nation to overcome the labour and productivity challenges that are inherent to its limited size and lack of natural resources. Over time this strategic focus has allowed Singapore to develop into a global leader in the AI domain and earn broad recognition as a frontrunner in the field. This research indicates that Singapore's emphasis on AI as a strategic national priority drives broad impact across the nation's research, technology development and deployment, as well as its governance.

The work done by the nation's AI research community ranks amongst the world's top contributors across AI subfields. It is globally competitive and outperforms multiple larger nations, both in terms of total output and in terms of citations. Moreover, scientists at Singapore's research institutions, relative to those at other nation's research institutions are particularly active in eight specific AI research areas, seven of which concern computer sciences and one of which concerns mathematics. In these areas, ranging from gradient-based optimisation and combinatorial optimisation to robotics (episodic memory, collaborative SLAM, biohybrid systems), and natural language processing (event extraction, sentiment analysis), institutions such as the National University of Singapore, Nanyang Technological University, and Singapore Management University show strong institutional leadership and lead global research in these areas. The interviews suggest that accessible and transparent funding helps reduce bureaucracy, creating a research environment that attracts top talent and supports high-quality research. This is further supported by the nation's long-term vision for AI, which provides clear research directions without steering academic work, while the concentration of world-class universities strengthens opportunities for collaboration.

Singapore's strong presence and leading role in specific AI research areas likely contributes to the nation's success in developing and deploying AI technologies. Compared to other AI research areas, the eight areas in which Singapore's AI research community plays a leading role are characterised by relatively high industry participation. This suggests that Singapore's overarching research direction is focused on topics relevant to industry and that the nation is effective at engaging industry actors and incorporating their input. The expert interviews indicate that Singapore's financial services, healthcare, and public sectors are at the forefront of AI adoption, using applications that enhance automation, decision-making, analytics, and customer engagement. Experts also observe a growing trend toward narrow, purpose-built AI applications, which can be more easily integrated into existing workflows. This approach helps enterprises overcome the challenges of incorporating novel technologies into established systems and IT landscapes. To maintain Singapore's leadership in AI development and deployment, this study identifies four key focus areas. First, accelerating AI adoption among SMEs is essential, as these organisations constitute a significant part of Singapore's economy but have been slow to adopt AI technologies. Second, although large enterprises are leading AI adoption in Singapore, they face challenges in integrating the technology with legacy IT systems and aligning it with broader business processes. Third, Singapore is tackling the limited availability of large datasets and compute, which are global bottlenecks in AI development. These challenges are particularly pronounced for

Singapore due to the need for locally relevant data, the country's small geographic size, and its tropical climate, which limits space for data centers and makes conventional cooling methods less efficient and more costly. Finally, Singapore's emphasis on building AI solutions that are both relevant and trustworthy requires that systems are tailored to the country's unique cultural, linguistic, and regulatory context. This requires AI applications to be localised, which in turn depends on high-quality datasets relevant to Singapore's context. Such datasets are often scarce, and localisation methods can be resource-intensive.

For Singapore, the rapid development and deployment of AI technologies has been accompanied by a growing awareness of their risks. The nation's approach is often described as 'careful yet ambitious,' reflecting a pragmatic balance between innovation and risk management. The nation strikes this balance through an AI governance approach grounded in four fundamental principles: transparency, explainability, fairness and human-centricity. These principles guide Singapore's overall AI strategy, recognising that leveraging AI technologies for the public good requires safety and accountability. This has resulted in an approach to AI governance that is characterised by its soft-law nature, consultation-focused multistakeholder governance model, and tiered sector-specificity. First, the soft law nature of Singapore's approach to AI governance enables that nation to be flexible and adaptable in governing rapidly evolving AI technologies. Rather than imposing rigid, binding rules, the government issues guidelines and frameworks that can be updated as technology and risks evolve. Second, the consultation-focused multistakeholder governance model employed by Singapore builds on broad collaborations between government, industry, and academia. Through continuous consultations, stakeholders share expertise, identify emerging risks, and co-develop governance frameworks such as the Model AI Governance Framework. This participatory process ensures that policies remain grounded in practical realities while reflecting diverse perspectives. Last, the nation employs a sector-specific focus that recognises cross-sectoral (horizontal) and industry-specific (vertical) risks. Broadly oriented government bodies, such as the MDDI's National AI Group, the IMDA, and the PDPC, oversee cross-sectoral risks, while sectoral regulators focus on risks within their respective industries. For instance, the Monetary Authority of Singapore manages AI governance in the financial services sector, whereas the Ministry of Health leads governance efforts in healthcare. As such, Singapore has adopted an AI governance approach that is mindful of both the inherent and evolving risks of AI, while remaining aligned with the nation's pro-innovation and business-friendly environment. This approach stands in contrast to the EU model of AI governance. While the EU has adopted a centralized, top-down framework that emphasizes regulatory uniformity and strong rights-based safeguards, Singapore's model is adaptive and collaborative, allowing for rapid updates and sector-specific customisation.

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