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AI Development and Deployment in Singapore
ESF Research Brief No.2

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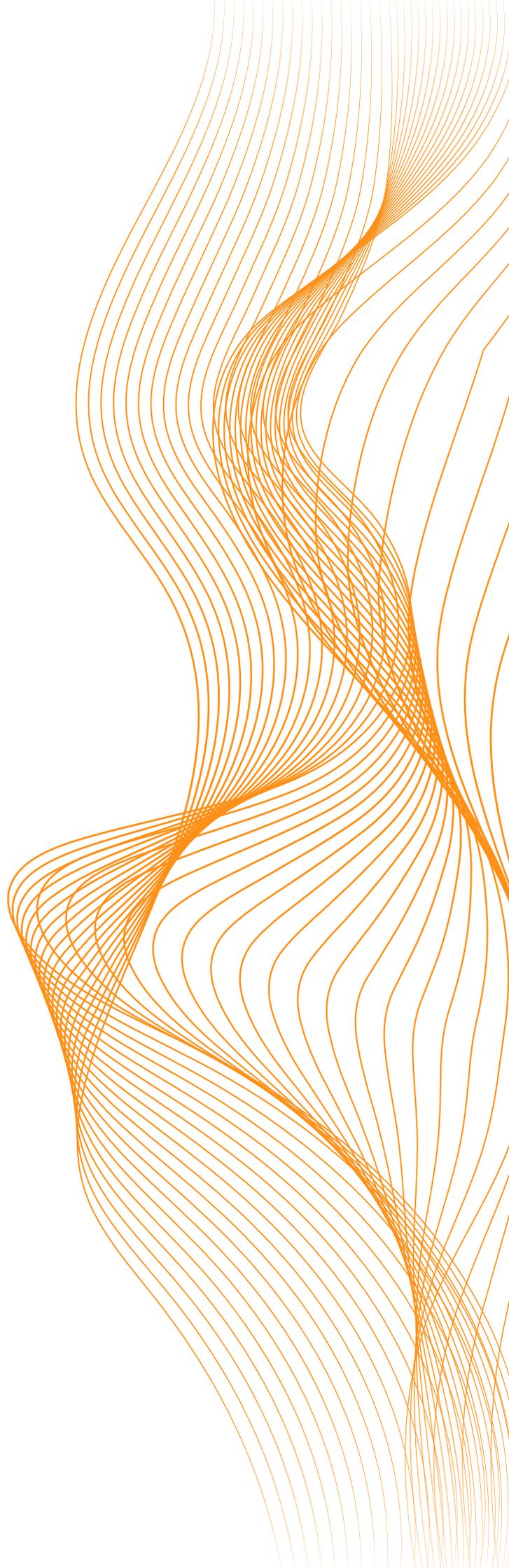
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Content

1 Introduction

Singapore leverages AI technology to transform its economy and overcome labour and productivity constraints caused by its small geographic size and lack of natural resources. To this end, the city-state released its first National AI Strategy in 2019, charting a course to becoming a global hub for developing and deploying AI technologies. Currently, Singapore is broadly recognised as an AI leader and considered one of the most AI-ready countries in the world. This makes Singapore's industry, research institutions, and administrative bodies potentially valuable partners for collaboration. Moreover, Singapore has developed a thriving AI ecosystem that engages the national research community, the private sector, and the public sector. This experience in building a national AI ecosystem offers valuable learning opportunities.

This research project has therefore examined the priorities and strengths of Singapore's AI ecosystem by:

- examining the work done by Singapore's AI research community;

- exploring the types of AI applications being developed and deployed; and

- analysing Singapore's approach to AI governance.

2 Structure and method

This second Research Brief presents an overview of the findings with regard to the types of AI applications being developed and deployed, building on the previous brief by examining how Singapore leverages the knowledge generated by its AI research community and the types of AI applications being developed. Additionally, it considers the sectors in which such AI applications are being applied and current constraints to broader AI adoption. The findings presented here are based on semi-structured expert interviews, the Emerging Technology Observatory's (ETO) Map of Science, and a review of the relevant literature.[1] The subsequent third Research Brief will build on this by outlining Singapore's approach to risk management.

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1   The ETO is a nonprofit public platform, aimed at collecting, linking, and transforming information from diverse source into data resources on the global emerging technology landscape. It is an initiative of the Centre for Security and Emerging Technology at Georgetown University. Emerging Technology Observatory, *Country Activity Tracker: Artificial Intelligence*, https://cat.eto.tech; Emerging Technology Observatory, *Map of Science*, https://sciencemap.eto.tech.

AI development and deployment

Singapore is widely recognised for its high level of development and its rapid transformation into an industrialised, high-GDP economy. Since gaining independence in 1965, it has sustained rapid and consistent economic growth while keeping inflation low despite the challenges posed by its small geographic size. Disciplined governance, strategic long-term planning, and institutional strength were essential drivers in attracting the foreign investments that drove this process. As a result, Singapore is often cited as an example of how long-term vision, effective governance, and a business-oriented approach to trade accelerates economic and social development.

Past	Challenge	Future
Singapore's long-term vision, effective governance, and business-oriented approach to trade has created consistent economic growth.	Singapore's small geographic size poses challenges to continued economic growth through labour and productivity constraints.	Singapore envisions that AI technologies will help the nation overcoming these constraints, thereby sustaining economic growth.

Although Singapore has been highly successful in overcoming the constraints of its limited geography, its unique position as a small yet highly developed island nation continues to pose challenges for the future. Among these, challenges related to labour and productivity constraints are likely to become increasingly significant. To address these challenges, Singapore's government has turned to AI technologies as a means of offsetting the constraints that are inherent to being a small city-state.

Considering the essential role AI technologies are envisioned to play in sustaining Singapore's economic growth, its government has designated AI as a strategic national priority. To this end, Singapore launched its first National AI Strategy in 2019, outlining plans to become a leader in AI and to use the technology to transform its economy, government, and society for both economic growth and social benefit. With the rapid and transformative developments in artificial intelligence, particularly generative AI, the strategy was updated in 2023 with the launch of National AI Strategy 2.0. The new version reflects a shift from a project-based to a systemic approach, and frames AI as a necessity rather than an opportunity, while recognising risk management as a cornerstone to responsible development.

Singapore therefore expects AI to transform leading economic sectors such as manufacturing, financial services, and transport & logistics. By integrating AI into Smart Nation Priorities such as healthcare, education & manpower, and public service delivery, it also anticipates significant social impact. At the same time, the strategy acknowledges that further scientific advances are needed to realise such effects.
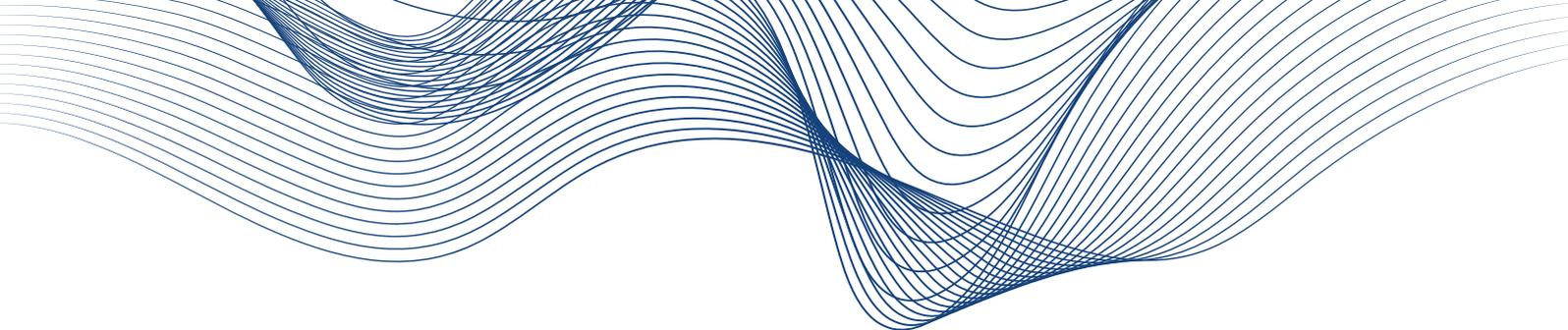
Given the relative immaturity of current AI capabilities, risks remain uncertain and unpredictable, a concern heightened by the expectation that AI will be applied across many industries and will continue to evolve over time.

Singapore is therefore seeking to stimulate AI development and deployment while simultaneously managing the uncertain and unpredictable risks associated with the technology. Its experiences in this regard provide valuable guidance for countries and businesses seeking to capture the technology's benefits while anticipating and mitigating its risks.

4 Patenting activity and industry involvement in Singapore's AI research

Singapore's AI research community conducts pioneering research. As outlined in the previous Research Brief, the ETO's Country Activity Tracker and Map of Science indicate particularly strong involvement in eight research clusters. The dataset draws on the Lens's patent database, which makes it possible to track patenting activity generated by these research clusters, thereby providing insights into the translational potential of the work done by these clusters. Patenting activity was examined using three metrics, whilst an additional metric was used to evaluate industry involvement:

- *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.[2]

- *%-Industry affiliated* gives the percentage of articles in the cluster that involve at least one author connected to industry.[3]

In examining the patenting activity of Singapore's AI research clusters, their metrics were benchmarked against those of other AI research clusters within the same field of science.[4] Hence, the mathematics AI research cluster in which Singapore is active was benchmarked against all mathematics AI clusters,

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2   A normalization 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 seize.

3   ETO notes that many records lack information on the authors' industry connections, so the %-industry affiliated is like an undercount.

4   An AI research cluster is one where at least 50% of research output is AI-related, based on ETO's 'AI per-centage.
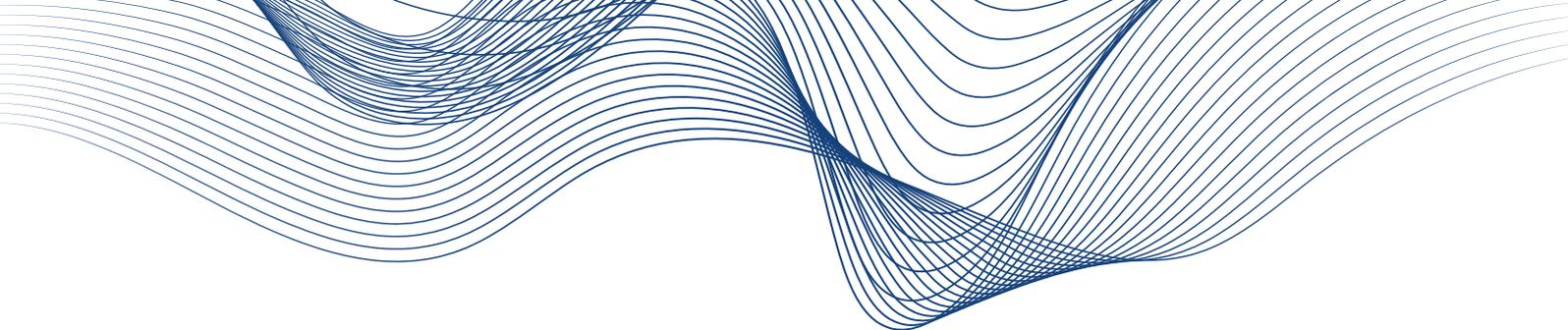
while computer science AI clusters were benchmarked against the broader set of all computer science AI clusters.[5]

Singapore is particularly active in the mathematics AI research cluster on nonconvex-nonconcave minimax optimization. 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.

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 normalized 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.

05 Applications of AI technologies in Singapore

Under Singapore's National AI strategy, AI is envisioned to be applied in two overarching domains. The application of AI in a research context stands to increase research productivity, while the use of AI in a business context is expected to transform business operations, thereby optimising efficiency and ultimately leading to greater economic productivity.

AI for science

Three AI capabilities are central to increasing future research productivity. First, AI systems are better equipped to deal with very large amounts of data than humans are. This enables such systems to find patterns and discover underlying principles in vast datasets much faster than humans can. Second, the application of AI technologies can make scientific simulations much more efficient.

This is especially relevant in the context of complex systems where scientists study the interactions between many components that shape such systems. These include:

- Natural systems, such as those relevant in ecosystem modelling.
- Physical systems, such as those relevant for the development of new materials.
- Social systems, such as those used to improve transportation networks.

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5   A minimum cluster size of 50 articles was used as the cut-off.
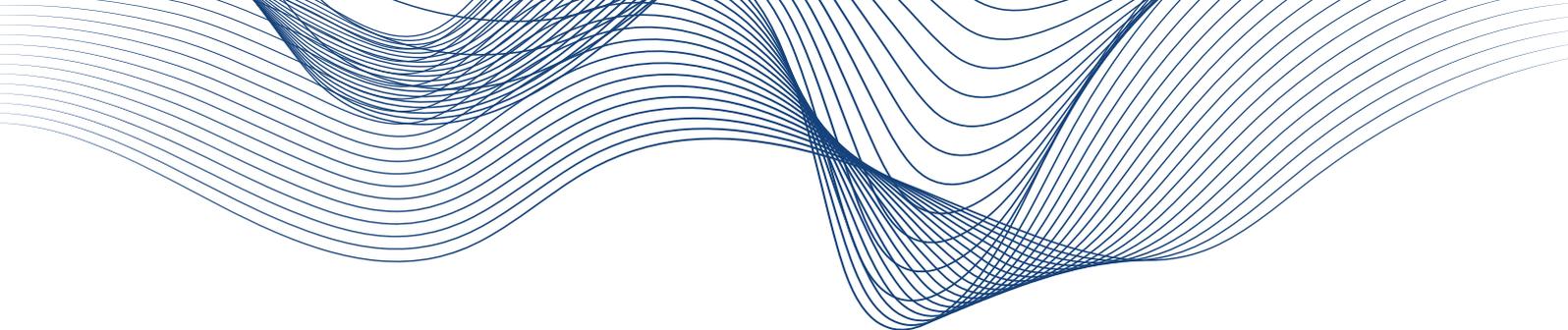
Third, the technology can enhance pattern recognition in data, thereby powering tools that help researchers synthesize knowledge, identify key insights, and track trends in research more easily. Such tools therefore allow researchers to review large bodies of academic literature, verify research findings 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.

These capabilities cut across all branches of science. It stands to affect the formal sciences through, for example, its ability to discover underlying mathematical structures in datasets. A broader impact is expected in the (applied) natural sciences, such as through the simulation of complex chemical reactions to predict their results, the modelling of bioactivity in new medicines, pattern recognition in astrophysics, and the analysis of theoretical materials to anticipate their properties.

AI for business operations

Current industry applications of AI technology generally serve to fulfil one of four goals: increase automation, enhance decision-making, improve business analytics, or boost customer engagement. In doing so, such applications deliver value by making businesses more efficient and effective. In Singapore, three sectors are leading the adoption of these applications.

Financial services

The financial services sector, first of all, uses AI-driven tools for back-end automation, customer service, risk management, and fraud detection. These tools might be used to predict credit or fraud risk, detect financial crime, or the processing of unstructured data for business analytics.

Healthcare

Second, the healthcare sector applies AI primarily in diagnostics and hospital operations. These applications include tools that interpret scans to predict medical conditions, such as retinal images for detecting eye disease or kidney scans for predicting kidney failure, as well as systems that forecast patients' likelihood of readmission or short-term emergency department arrivals.

Public sector

Finally, the public sector adopts AI to improve the efficiency of government services while also inspire broader public confidence in the technology, as Singapore's government views public sector adoption as a means to promote general adoption. It uses AI for citizen service automation, public housing and public transport, infrastructure management and security. Such applications leverage AI, for example, to improve the efficiency of job search and matching, predictive maintenance of public housing, enhanced security checks at border control checkpoints, and improved response to service disruptions of Singapore's rail network.

6 Conditions shaping future AI adoption

Singapore is widely recognised as a global leader in this emerging field. As the technology and its ecosystem mature, staying ahead will require a deep understanding of the technology itself, the organisations deploying it, and the local context in which it is applied. For Singapore, a small yet highly developed city-state with a vibrant AI ecosystem, four focus areas stand out as critical to maintaining Singapore's leadership.

AI adoption by SMEs

In Singapore, large enterprises are driving much of the progress in AI adoption. Yet SMEs, which contribute nearly half of the economy and employ more than two-thirds of the workforce, have been slower to adopt. While AI adoption among larger firms continues to rise, SMEs still lag behind.

Enterprise AI adoption

While large enterprises lead in AI adoption, they also encounter challenges. These challenges largely stem from the complexity of integrating rapidly evolving yet immature technologies into established IT systems. Adding to this, AI technologies are generally still in the early stages of development, making it especially difficult to anticipate and assess their associated risks. This introduces further challenges for large enterprises, as these organisations must understand and manage these risks by adapting their business processes, a task made more complicated when working with emerging technologies like AI.

Resource availability

Developing and fine-tuning AI models requires large amounts of data and considerable computer. These requirements are widely seen as key barriers to global AI development, but they are felt especially strongly in Singapore. In terms of data, Singapore's small population limits the volume of data that can be generated locally. Moreover, the city-state's limited land area and high population density inherently restrict its capacity to build local data centres.

Localisation

The localisation of AI technologies is the process of adapting them to function within a specific local context. By considering geographic, cultural, linguistic, and regulatory factors, AI can be made more relevant, usable, and accurate for local users. Doing so depends on high-quality datasets that capture local conditions accurately. However, Singapore's small population limits the availability of such datasets, making AI localisation especially challenging.

Key insights

- Singapore considers AI a strategic national priority as it presents key opportunities in sustaining the nation's economic growth despite geographic constraints.

- Singapore's AI research community is especially active in research clusters that have strong industry participation.

- AI technologies are expected to increase research productivity by enhancing pattern recognition, improving scientific simulations, and supporting knowledge synthesis.

- Financial services, healthcare, and the public sector are leading AI adoption through applications that increase automation, enhance decision-making, improve business analytics, or boost customer engagement.

- Four focus areas are key in maintaining Singapore's AI leadership position: increasing AI adoption by SME's, supporting large enterprises in overcoming their unique challenges, reducing dependence on compute and data in AI model development and fine-tuning, and building capabilities that enable AI applications to operate effectively in local contexts.

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