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AI by McKinsey

The next frontier for AI in China could add $600 billion to its economy

By 2030, AI could disrupt transportation and other key sectors in China, adding significant economic value—but only if strategic cooperation and capability building occur across multiple dimensions.

by Kai Shen, Xiaoxiao Tong, Ting Wu, and Fangning Zhang

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In the past decade, China has built a solid foundation to support its AI economy and made significant contributions to AI globally. Stanford University's AI Index, which assesses AI advancements worldwide across various metrics in research, development, and economy, ranks China among the top three countries for global AI vibrancy.[1] On research, for example, China produced about one-third of both AI journal papers and AI citations worldwide in 2021. In economic investment, China accounted for nearly one-fifth of global private investment funding in 2021, attracting $17 billion for AI start-ups.[2]

Today, AI adoption is high in China in finance, retail, and high tech, which together account for more than one-third of the country's AI market (see sidebar "Five types of AI companies in China").[3] In tech, for example, leaders Alibaba and ByteDance, both household names in China, have become known for their highly personalized AI-driven consumer apps. In fact, most of the AI applications that have been widely adopted in China to date have been in consumer-facing industries, propelled by the world's largest internet consumer base and the ability to engage with consumers in new ways to increase customer loyalty, revenue, and market valuations.

So what's next for AI in China?

In the coming decade, our research indicates that there is tremendous opportunity for AI growth in new sectors in China, including some where innovation and R&D spending have traditionally lagged global counterparts: automotive, transportation, and logistics; manufacturing; enterprise software; and healthcare and life sciences. (See sidebar "About the research.") In these sectors, we see clusters of use cases where AI can create upwards of $600 billion in economic value annually. (To provide a sense of scale, the 2021 gross domestic product in Shanghai, China's most populous city of nearly 28 million, was roughly $680 billion.) In some cases, this value will come from revenue generated by AI-enabled offerings, while in other cases, it will be generated by cost savings through greater efficiency and productivity. These clusters are likely to become battlegrounds for companies in each sector that will help define the market leaders.

Unlocking the full potential of these AI opportunities typically requires significant investments—in some cases, much more than leaders might expect—on multiple fronts, including the data and technologies that will underpin AI systems, the right talent and organizational mindsets to build these systems, and new business models and partnerships to create data

[1] "Global AI Vibrancy Tool: Who's leading the global AI race?" Artificial Intelligence Index, Stanford Institute for Human-Centered Artificial Intelligence (HAI), Stanford University, 2021 ranking.
[2] Daniel Zhang et al., *Artificial Intelligence Index report 2022*, Stanford Institute for Human-Centered Artificial Intelligence (HAI), Stanford University, March 2022, Figure 4.2.6, "Private investment in AI by geographic area, 2013–21."
[3] iResearch, *iResearch serial market research on China's AI industry III*, December 2020.

Five types of AI companies in China

In China, we find that AI companies typically fall into one of five main categories:

1. *Hyperscalers* develop end-to-end AI technology capability and collaborate within the ecosystem to serve both business-to-business and business-to-consumer companies.
2. *Traditional industry companies* serve customers directly by developing and adopting AI in internal transformation, new-product launch, and customer services.
3. *Vertical-specific AI companies* develop software and solutions for specific domain use cases.
4. *AI core tech providers* provide access to computer vision, natural-language processing, voice recognition, and machine learning capabilities to develop AI systems.
5. *Hardware companies* provide the hardware infrastructure to support AI demand in computing power and storage.

About the research

This research is based on field interviews with more than 50 experts within McKinsey and across industries, along with extensive analysis of McKinsey market assessments in Europe, the United States, Asia, and China specifically between October and November 2021. In performing our analysis, we looked outside of commercial sectors, such as finance and retail, where there are already mature AI use cases and clear adoption. In emerging sectors with the highest value-creation potential, we focused on the domains where AI applications are currently in market-entry stages and could have a disproportionate impact by 2030. Applications in these sectors that either are in the early-exploration stage or have mature industry adoption, such as manufacturing-operations optimization, were not the focus for the purpose of the study.

ecosystems, industry standards, and regulations. In our work and global research, we find many of these enablers are becoming standard practice among companies getting the most value from AI.[4]

To help leaders and investors marshal their resources to accelerate, disrupt, and lead in AI, we dive into the research, first sharing where the biggest opportunities lie in each sector and then outlining the core enablers to be tackled first.

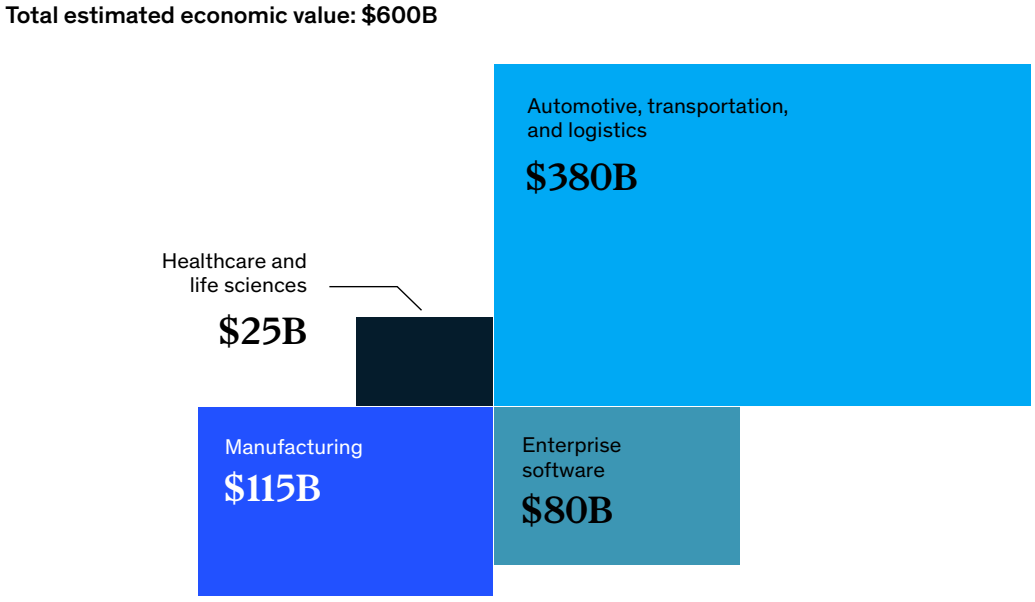
Following the money to the most promising sectors

We looked at the AI market in China to determine where AI could deliver the most value in the future. We studied market projections at length and dug deep into country and segment-level reports worldwide to see where AI was delivering the greatest value across the global landscape. We then spoke in depth with experts across sectors in China to understand where the greatest opportunities could emerge next. Our research led us to several sectors: automotive, transportation, and logistics, which are collectively expected to contribute the majority—around 64 percent—of the $600 billion opportunity; manufacturing, which will drive another 19 percent; enterprise software, contributing 13 percent; and healthcare and life sciences, at 4 percent of the opportunity (Exhibit 1).

Within each sector, our analysis shows the value-creation opportunity concentrated within only two to three domains. These are typically in areas where

Exhibit 1

Four key sectors offer China the highest potential economic value from AI.



Source: Expert interviews and McKinsey analysis, October–November 2021

[4] "The state of AI in 2021," McKinsey, December 8, 2021.

private-equity and venture-capital-firm investments have been high in the past five years and successful proof of concepts have been delivered.

Automotive, transportation, and logistics

China's auto market stands as the largest in the world, with the number of vehicles in use surpassing that of the United States. The sheer size—which we estimate to grow to more than 300 million passenger vehicles on the road in China by 2030—provides a fertile landscape of AI opportunities. Indeed, our research finds that AI could have the greatest potential impact on this sector, delivering more than $380 billion in economic value. This value creation will likely be generated predominantly in three areas: autonomous vehicles, personalization for auto owners, and fleet asset management (Exhibit 2).

Autonomous, or self-driving, vehicles. Autonomous vehicles make up the largest portion of value creation in this sector ($335 billion). Some of this new value is expected to come from a reduction in financial losses, such as medical, first-responder, and vehicle costs. Roadway accidents stand to decrease an estimated 3 to 5 percent annually as autonomous vehicles actively navigate their surroundings and make real-time driving decisions without being subject to the many distractions, such as text messaging, that tempt humans. Value would also come from savings realized by drivers as cities and enterprises replace passenger vans and buses with shared autonomous vehicles.[5]

Already, significant progress has been made by both traditional automotive OEMs and AI players to advance autonomous-driving capabilities to level 4 (where the driver doesn't need to pay attention but can take over controls) and level 5 (fully autonomous capabilities in which inclusion of a steering wheel is optional). For instance, WeRide, which achieved level 4 autonomous-driving capabilities,[6] completed a pilot of its Robotaxi in Guangzhou, with nearly 150,000 trips in one year without any accidents with active liability.[7]

Exhibit 2

In the automotive, transportation, and logistics sector, autonomous driving could see the most impact from AI.

Total estimated economic value:
$380B

Top unlocks: Technology, data

1 Autonomous driving

$335B

Use computer vision, machine learning, and neural networks to enable vehicles to map surroundings, detect and predict road traffic, and make real-time driving decisions, reducing number of accidents and costs.

2 Personalized updates

$30B

Apply recommendation techniques on connected-car data (vehicle operations, driver behavior, entertainment interaction) to tailor recommendations for hardware and software updates and driving experience.

3 Fleet asset management

$15B

Apply operations-research optimizers on connected fleet's IoT data to optimize fleet operations and route planning, reducing fuel consumption and maintenance cost.

Source: Expert interviews and McKinsey analysis, October–November 2021

[5] Estimate based on McKinsey analysis. Key assumptions: 3 percent of light vehicles and 5 percent of heavy vehicles on the road in China to be replaced by shared autonomous vehicles; accidents to be reduced by 3 to 5 percent with adoption of autonomous vehicles.
[6] Based on WeRide's own assessment/claim on its website.
[7] The pilot was conducted between November 2019 and November 2020.

Personalized experiences for car owners. By using AI to analyze sensor and GPS data—including vehicle-parts conditions, fuel consumption, route selection, and steering habits—car manufacturers and AI players can increasingly tailor recommendations for hardware and software updates and personalize car owners' driving experience. Automaker NIO's advanced driver-assistance system and battery-management system, for instance, can track the health of electric-car batteries in real time, diagnose usage patterns, and optimize charging cadence to improve battery life span while drivers go about their day. Our research finds this could deliver $30 billion in economic value by reducing maintenance costs and unanticipated vehicle failures, as well as generating incremental revenue for companies that identify ways to monetize software updates and new capabilities.[8]

Fleet asset management. AI could also prove critical in helping fleet managers better navigate China's immense network of railway, highway, inland waterway, and civil aviation routes, which are some of the longest in the world. Our research finds that $15 billion in value creation could emerge as OEMs and AI players specializing in logistics develop operations research optimizers that can analyze IoT data and identify more fuel-efficient routes and lower-cost maintenance stops for fleet operators.[9] One automotive OEM in China now offers fleet owners and operators an AI-driven management system for monitoring fleet locations, tracking fleet conditions, and analyzing trips and routes. It is estimated to save up to 15 percent in fuel and maintenance costs.

Manufacturing

In manufacturing, China is evolving its reputation from a low-cost manufacturing hub for toys and clothes to a leader in precision manufacturing for processors, chips, engines, and other high-end components. Our findings show AI can help facilitate this shift from manufacturing execution to manufacturing innovation and create $115 billion in economic value (Exhibit 3).

Exhibit 3

Two domains in the manufacturing sector could deliver $115 billion in economic value.

Total estimated economic value:

$115B

Top unlocks: Technology, data, talent

1 Process-design R&D

$100B

Leverage digital twins and machine learning to simulate, test, and validate manufacturing-process outcomes before commencement of mass production, reducing significant R&D costs in manufacturing-process design.

2 Product R&D

$15B

Leverage digital twins and machine learning in new-product-design testing and validation, rapidly predicting product-design outcomes, reducing R&D costs, and potentially creating new products and improving product quality.

Source: Expert interviews and McKinsey analysis, October–November 2021

[8] Estimate based on McKinsey analysis. Key assumptions: AI will generate 5 to 10 percent savings in customer maintenance fee (hardware updates); car manufacturers and AI players will monetize software updates for 15 percent of fleet.
[9] Estimate based on McKinsey analysis. Key assumptions: 5 to 15 percent cost reduction in automotive fleet fuel consumption and maintenance; approximately 2 percent cost reduction for aircrafts, vessels, and trains.

The majority of this value creation ($100 billion) will likely come from innovations in process design through the use of various AI applications, such as collaborative robotics that create the next-generation assembly line, and digital twins that replicate real-world assets for use in simulation and optimization engines.[10] With digital twins, manufacturers, machinery and robotics providers, and system automation providers can simulate, test, and validate manufacturing-process outcomes, such as product yield or production-line productivity, before commencing large-scale production so they can identify costly process inefficiencies early. One local electronics manufacturer uses wearable sensors to capture and digitize hand and body movements of workers to model human performance on its production line. It then optimizes equipment parameters and setups—for example, by changing the angle of each workstation based on the worker's height—to reduce the likelihood of worker injuries while improving worker comfort and productivity.

The remainder of value creation in this sector ($15 billion) is expected to come from AI-driven improvements in product development.[11] Companies could use digital twins to rapidly test and validate new product designs to reduce R&D costs, improve product quality, and drive new product innovation. On the global stage, Google has offered a glimpse of what's possible: it has used AI to rapidly assess how different component layouts will alter a chip's power consumption, performance metrics, and size. This approach can yield an optimal chip design in a fraction of the time design engineers would take alone.

Enterprise software

As in other countries, companies based in China are undergoing digital and AI transformations, leading to the emergence of new local enterprise-software industries to support the necessary technological foundations.

Solutions delivered by these companies are estimated to deliver another $80 billion in economic value (Exhibit 4). Offerings for cloud and AI tooling are expected to provide more than half of this value creation ($45 billion).[12] In one case, a local cloud provider serves more than 100 local banks and insurance companies in China with an integrated data platform that enables them to operate across both cloud and on-premises environments and reduces the cost of database development and storage. In another case, an AI tool provider in China has developed a shared AI algorithm platform that can help its data scientists automatically train, predict, and update the model for a given prediction problem. Using the shared platform has reduced model production time from three months to about two weeks.

AI-driven software-as-a-service (SaaS) applications are expected to contribute the remaining $35 billion in economic value in this category.[13] Local SaaS application developers can apply multiple AI techniques (for instance, computer vision, natural-language processing, machine learning) to help companies make predictions and decisions across enterprise functions in finance and tax, human resources, supply chain, and cybersecurity. A leading financial institution in China has deployed a local AI-driven SaaS solution that uses AI bots to offer personalized training recommendations to employees based on their career path.

Healthcare and life sciences

In recent years, China has stepped up its investment in innovation in healthcare and life sciences with AI. China's "14th Five-Year Plan" targets 7 percent annual growth by 2025 for R&D expenditure, of which at least 8 percent is devoted to basic research.[14]

One area of focus is accelerating drug discovery and increasing the odds of success, which is a

[10] Estimate based on McKinsey analysis. Key assumptions: 40 to 50 percent cost reduction in manufacturing product R&D based on AI adoption rate in 2030 and improvement for manufacturing design by sub-industry (including chemicals, steel, electronics, automotive, and advanced industries).
[11] Estimate based on McKinsey analysis. Key assumptions: 10 percent cost reduction in manufacturing product R&D based on AI adoption rate in 2030 and improvement for product R&D by sub-industry (including electronics, machinery, automotive, and advanced industries).
[12] Estimate based on McKinsey analysis. Key assumptions: 12 percent CAGR for cloud database in China; 20 to 30 percent CAGR for AI tooling.
[13] Estimate based on McKinsey analysis. Key assumptions: 17 percent CAGR for software market; 100 percent SaaS penetration rate in China by 2030; 90 percent of the use cases empowered by AI in enterprise SaaS applications.
[14] "'14th Five-Year Plan' Digital Economy Development Plan," State Council of the People's Republic of China, January 12, 2022.

Exhibit 4

Enterprise-software companies could generate the most value by providing AI solutions in SaaS, data, and middleware to industry.

Total estimated economic value:
$80B

Top unlocks: Technology, regulation

1 Data & middleware

$45B

Adopt cloud data warehouses to reduce operations and maintenance costs; leverage AI algorithm APIs to streamline production of core AI models; and adopt MLOps to automatically deploy and maintain optimal models.

2 SaaS applications

$35B

Apply facial recognition, computer vision, and natural-language processing to process images and voice data, and use machine learning algorithms to make predictions and decisions across enterprise functions in finance and tax, human resources, supply chain, and cybersecurity.

Source: Expert interviews and McKinsey analysis, October–November 2021

significant global issue. In 2021, global pharma R&D spend reached $212 billion, compared with $137 billion in 2012, with an approximately 5 percent compound annual growth rate (CAGR). Drug discovery takes 5.5 years on average, which not only delays patients' access to innovative therapeutics but also shortens the patent protection period that rewards innovation. Despite improved success rates for new-drug development, only the top 20 percent of pharmaceutical companies worldwide realized a breakeven on their R&D investments after seven years.

Another top priority is improving patient care, and Chinese AI start-ups today are working to build the country's reputation for providing more accurate and reliable healthcare in terms of diagnostic outcomes and clinical decisions.

Our research suggests that AI in R&D could add more than $25 billion in economic value in three specific areas: faster drug discovery, clinical-trial optimization, and clinical-decision support (Exhibit 5).

Rapid drug discovery. Novel drugs (patented prescription drugs) currently account for less than 30 percent of the total market size in China (compared with more than 70 percent globally), indicating a significant opportunity from introducing novel drugs empowered by AI in discovery. We estimate that using AI to accelerate target identification and novel molecules design could contribute up to $10 billion in value.[15] Already more than 20 AI start-ups in China funded by private-equity firms or local hyperscalers are collaborating with traditional pharmaceutical companies or independently working to develop novel therapeutics. Insilico Medicine, by using an end-to-end generative AI engine for target identification, molecule design, and lead optimization, discovered a preclinical candidate for pulmonary fibrosis in less than 18 months at a cost of under $3 million. This represented a significant reduction from the

[15] Estimate based on McKinsey analysis. Key assumptions: 35 percent of AI enablement on novel drug discovery; 10 percent revenue from novel drug development through AI empowerment.

Exhibit 5

Three domains in the healthcare and life sciences sector could deliver $25 billion in economic value.

Total estimated economic value:
$25B

Top unlocks: Technology, data, regulation

1 Drug discovery

$10B

Use AI technology for rapid target discovery and novel molecules design for different identified drug targets, speeding up new-drug discovery and time to market and reducing cost of drug R&D.

2 Clinical-trial optimization

$10B

Use natural-language processing and machine learning to collect and analyze data to predict clinical-trial outcomes and optimize clinical-study design, reducing time and cost of clinical trials and speeding up time to market of new drugs.

3 Clinical-decision support

$5B

Apply machine learning algorithms to medical images or medical data to predict diagnostic outcomes and support clinical decisions, reducing cost of diagnostics while improving reliability and accuracy.

Source: Expert interviews and McKinsey analysis, October–November 2021

average timeline of six years and an average cost of more than $18 million from target discovery to preclinical candidate. This antifibrotic drug candidate has now successfully completed a Phase 0 clinical study and entered a Phase I clinical trial.

Clinical-trial optimization. Our research suggests that another $10 billion in economic value could result from optimizing clinical-study designs (process, protocols, sites), optimizing trial delivery and execution (hybrid trial-delivery model), and generating real-world evidence.[16] These AI use cases can reduce the time and cost of clinical-trial development, provide a better experience for patients and healthcare professionals, and enable higher quality and compliance. For instance, a global top 20 pharmaceutical company leveraged AI in combination with process improvements to reduce the clinical-trial enrollment timeline by 13 percent and save 10 to 15 percent in external costs. The global pharmaceutical company prioritized three areas for its tech-enabled clinical-trial development. To accelerate trial design and operational planning, it utilized the power of both internal and external data for optimizing protocol design and site selection. For streamlining site and patient engagement, it established an ecosystem with API standards to leverage internal and external innovations. To establish a clinical-trial development cockpit, it aggregated and visualized operational trial data to enable end-to-end clinical-trial operations with full transparency so it could predict potential risks and trial delays and proactively take action.

Clinical-decision support. Our findings indicate that the use of machine learning algorithms on medical images and data (including examination results and symptom reports) to predict diagnostic outcomes

[16] Estimate based on McKinsey analysis. Key assumptions: 30 percent AI utilization in clinical trials; 30 percent time savings from real-world-evidence expedited approval.

and support clinical decisions could generate around $5 billion in economic value.[17] A leading AI start-up in medical imaging now applies computer vision and machine learning algorithms on optical coherence tomography results from retinal images. It automatically searches and identifies the signs of dozens of chronic illnesses and conditions, such as diabetes, hypertension, and arteriosclerosis, expediting the diagnosis process and increasing early detection of disease.

How to unlock these opportunities

During our research, we found that realizing the value from AI would require every sector to drive significant investment and innovation across six key enabling areas (Exhibit 6). The first four areas are data, talent, technology, and significant work to shift mindsets as part of adoption and scaling efforts. The remaining two, ecosystem orchestration and navigating regulations, can be considered collectively as market collaboration and should be addressed as part of strategy efforts.

Some specific challenges in these areas are unique to each sector. For example, in automotive, transportation, and logistics, keeping pace with the latest advances in 5G and connected-vehicle technologies (commonly referred to as V2X) is crucial to unlocking the value in that sector. Those in healthcare will want to stay current on advances in AI explainability; for providers and patients to trust the AI, they must be able to understand why an algorithm made the decision or recommendation it did.

Broadly speaking, four of these areas—data, talent, technology, and market collaboration—stood out as common challenges that we believe will have an outsized impact on the economic value achieved. Without them, tackling the others will be much harder.

Data

For AI systems to work properly, they need access to high-quality data, meaning the data must be available, usable, reliable, relevant, and secure. This can be challenging without the right foundations for storing, processing, and managing the vast volumes of data being generated today. In the automotive sector, for instance, the ability to process and support up to two terabytes of data per car and road data daily is necessary for enabling autonomous vehicles to understand what's ahead and delivering personalized experiences to human drivers. In healthcare, AI models need to take in vast amounts of omics[18] data to understand diseases, identify new targets, and design new molecules.

Companies seeing the highest returns from AI—more than 20 percent of earnings before interest and taxes (EBIT) contributed by AI—offer some insights into what it takes to achieve this. McKinsey's 2021 Global AI Survey shows that these high performers are much more likely to invest in core data practices, such as rapidly integrating internal structured data for use in AI systems (51 percent of high performers versus 32 percent of other companies), establishing a data dictionary that is accessible across their enterprise (53 percent versus 29 percent), and developing well-defined processes for data governance (45 percent versus 37 percent).[19]

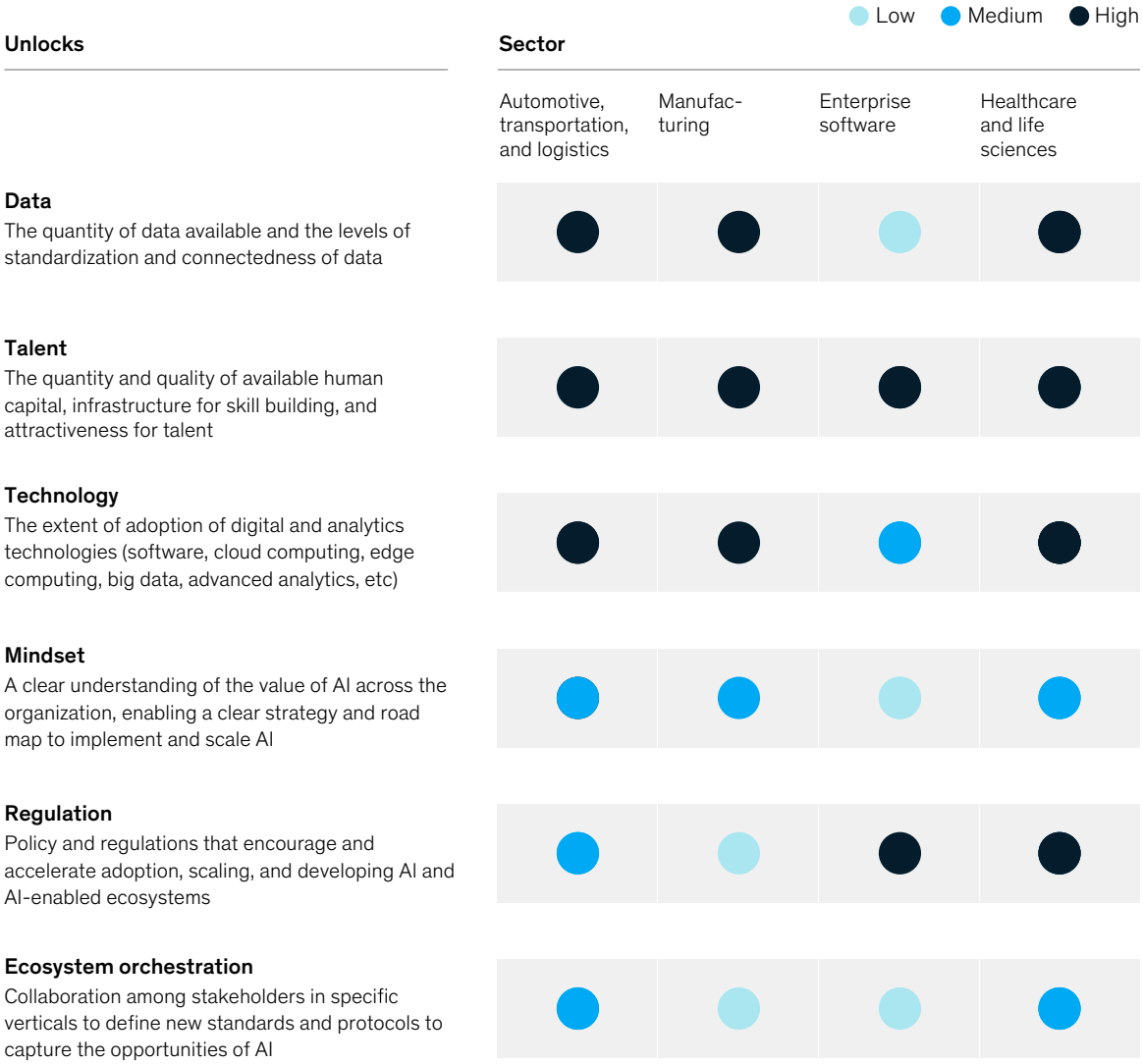
Participation in data sharing and data ecosystems is also crucial, as these partnerships can lead to insights that would not be possible otherwise. For instance, medical big data and AI companies are now partnering with a wide range of hospitals and research institutes, integrating their electronic medical records (EMR) with publicly available medical-research data and clinical-trial data from pharmaceutical companies or contract research organizations. The goal is to facilitate drug discovery, clinical trials, and decision making at the point of care so providers can better identify the right treatment procedures and plan for each patient, thus increasing treatment effectiveness and reducing chances of adverse side effects. One such company, Yidu Cloud, has provided big data platforms and solutions to more than 500 hospitals in China and has, upon authorization, analyzed more

[17] Estimate based on McKinsey analysis. Key assumptions: 10 percent higher early-stage cancer diagnosis rate through more accurate AI diagnosis; 10 percent increase in efficiency enabled by AI.
[18] "Omics" includes genomics, epigenomics, transcriptomics, proteomics, metabolomics, interactomics, pharmacogenomics, and diseasomics.
[19] "The state of AI in 2021," December 8, 2021.

Exhibit 6

All four sectors must make investments in six key areas to unlock the full economic value potential from AI, but their level of importance varies.

Level of importance in area of investment for value creation, by sector



Source: Expert interviews and McKinsey analysis, October–November 2021

than 1.3 billion healthcare records since 2017 for use in real-world disease models to support a variety of use cases including clinical research, hospital management, and policy making.

Talent

In our experience, we find it nearly impossible for businesses to deliver impact with AI without business domain knowledge. Knowing what questions to ask in each domain can determine the success or failure of a given AI effort. As a result, organizations in all four sectors (automotive, transportation, and logistics; manufacturing; enterprise software; and healthcare and life sciences) can benefit from systematically upskilling existing AI experts and knowledge workers to

become AI translators—individuals who know what business questions to ask and can translate business problems into AI solutions. We like to think of their skills as resembling the Greek letter pi (π). This group has not only a broad mastery of general management skills (the horizontal bar) but also spikes of deep functional knowledge in AI and domain expertise (the vertical bars).

To build this talent profile, some companies upskill technical talent with the requisite skills. One AI start-up in drug discovery, for instance, has created a program to train newly hired data scientists and AI engineers in pharmaceutical domain knowledge such as molecule structure and characteristics. Company executives credit this deep domain knowledge among its AI experts with enabling the discovery of nearly 30 molecules for clinical trials. Other companies seek to arm existing domain talent with the AI skills they need. An electronics manufacturer has built a digital and AI academy to provide on-the-job training to more than 400 employees across different functional areas so that they can lead various digital and AI projects across the enterprise.

Technology maturity

McKinsey has found through past research that having the right technology foundation is a critical driver for AI success.[20] For business leaders in China, our findings highlight four priorities in this area:

Increasing digital adoption. There is room across industries to increase digital adoption. In hospitals and other care providers, many workflows related to patients, personnel, and equipment have yet to be digitized. Further digital adoption is required to provide healthcare organizations with the necessary data for predicting a patient's eligibility for a clinical trial or providing a physician with intelligent clinical-decision-support tools.

The same holds true in manufacturing, where digitization of factories is low. Implementing IoT sensors across manufacturing equipment and production lines can enable companies to accumulate the data necessary for powering digital twins.

Implementing data science tooling and platforms. The cost of algorithmic development can be high, and companies can benefit greatly from using technology platforms and tooling that streamline model deployment and maintenance, just as they benefit from investments in technologies to improve the efficiency of a factory production line. Some essential capabilities we recommend companies consider include reusable data structures, scalable computation power, and automated MLOps capabilities. All of these contribute to ensuring AI teams can work efficiently and productively.

Advancing cloud infrastructures. Our research finds that while the percent of IT workloads on cloud in China is almost on par with global survey numbers, the share on private cloud is much bigger due to security and data compliance concerns. As SaaS vendors and other enterprise-software providers enter this market, we advise that they continue to advance their infrastructures to address these concerns and provide enterprises with a clear value proposition. This will require further advances in virtualization, data-storage capacity, performance, elasticity and resilience, and technological agility to customize business capabilities, which enterprises have come to expect from their vendors.

Investments in AI research and advanced AI techniques. Many of the use cases described here will require fundamental advances in the underlying technologies and techniques. For instance, in manufacturing, additional research is needed to improve the performance of camera sensors and computer vision algorithms to detect and recognize objects in dimly lit environments, which can be common on factory floors. In life sciences, further innovation in wearable devices and AI algorithms is necessary to enable the collection, processing, and integration of real-world data in drug discovery, clinical trials, and clinical-decision-support processes. In automotive, advances for improving self-driving model accuracy and reducing modeling complexity are required to enhance how

[20] Ibid.

autonomous vehicles perceive objects and perform in complex scenarios.

For conducting such research, academic collaborations between enterprises and universities can advance what's possible.

Market collaboration

AI can present challenges that transcend the capabilities of any one company, which often gives rise to regulations and partnerships that can further AI innovation. In many markets globally, we've seen new regulations, such as Global Data Protection Regulation (GDPR) in Europe and the California Consumer Privacy Act in the United States, begin to address emerging issues such as data privacy, which is considered a top AI relevant risk in our 2021 Global AI Survey.[21] And proposed European Union regulations designed to address the development and use of AI more broadly will have implications globally.[22]

Our research points to three areas where additional efforts could help China unlock the full economic value of AI:

Data privacy and sharing. For individuals to share their data, whether it's healthcare or driving data, they need to have an easy way to give permission to use their data and have trust that it will be used appropriately by authorized entities and safely shared and stored. Guidelines related to privacy and sharing can create more confidence and thus enable greater AI adoption. A 2019 law enacted in China to improve citizen health, for instance, promotes the use of big data and AI by developing technical standards on the collection, storage, analysis, and application of medical and health data.[23]

Meanwhile, there has been significant momentum in industry and academia to build methods and frameworks to help mitigate privacy concerns. For example, the number of papers mentioning "privacy" accepted by the Neural Information Processing Systems, a leading machine learning conference, has increased sixfold in the past five years.[24]

Market alignment. In some cases, new business models enabled by AI will raise fundamental questions around the use and delivery of AI among the various stakeholders. In healthcare, for instance, as companies develop new AI systems for clinical-decision support, debate will likely emerge among government and healthcare providers and payers as to when AI is effective in improving diagnosis and treatment recommendations and how providers will be reimbursed when using such systems. In transportation and logistics, issues around how government and insurers determine culpability have already arisen in China following accidents involving both autonomous vehicles and vehicles operated by humans. Settlements in these accidents have created precedents to guide future decisions, but further codification can help ensure consistency and clarity.

Standard processes and protocols. Standards enable the sharing of data within and across ecosystems. In the healthcare and life sciences sectors, academic medical research, clinical-trial data, and patient medical data need to be well structured and documented in a uniform manner to accelerate drug discovery and clinical trials. A push by the National Health Commission in China to build a data foundation for EMRs and disease databases in 2018 has led to some movement here with the creation of a standardized disease database and EMRs for use in AI. However, standards and protocols around how the data are structured, processed, and connected can be beneficial for further use of the raw-data records.

Likewise, standards can also eliminate process delays that can derail innovation and scare off investors and talent. An example involves the acceleration of drug discovery using real-world evidence in Hainan's medical tourism zone; translating that success into transparent approval protocols can help ensure consistent licensing across the country and ultimately would build trust in new discoveries. On the manufacturing side, standards for how organizations label the various features of an object (such as the size and shape of

[21] Ibid.
[22] Misha Benjamin, Kevin Buehler, Rachel Dooley, and Peter Zipparo, "What the draft European Union AI regulations mean for business," McKinsey, August 10, 2021.
[23] Law of the People's Republic of China on Basic Medical and Health Care and the Promotion of Health, Article 49, 2019.
[24] *Artificial Intelligence Index report 2022*, March 2022, Figure 3.3.6.

a part or the end product) on the production line can make it easier for companies to leverage algorithms from one factory to another, without having to undergo costly retraining efforts.

Patent protections. Traditionally, in China, new innovations are rapidly folded into the public domain, making it difficult for enterprise-software and AI players to realize a return on their sizable investment. In our experience, patent laws that protect intellectual property can increase investors' confidence and attract more investment in this area.

AI has the potential to reshape key sectors in China. However, among business domains in these sectors with the most valuable use cases, there is no low-hanging fruit where AI can be implemented with little additional investment. Rather, our research finds that unlocking maximum potential of this opportunity will be possible only with strategic investments and innovations across several dimensions—with data, talent, technology, and market collaboration being foremost. Working together, enterprises, AI players, and government can address these conditions and enable China to capture the full value at stake.

Kai Shen and **Ting Wu** are partners in McKinsey's Shenzhen office, and **Xiaoxiao Tong** is a consultant in the Shanghai office, where **Fangning Zhang** is a partner.

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