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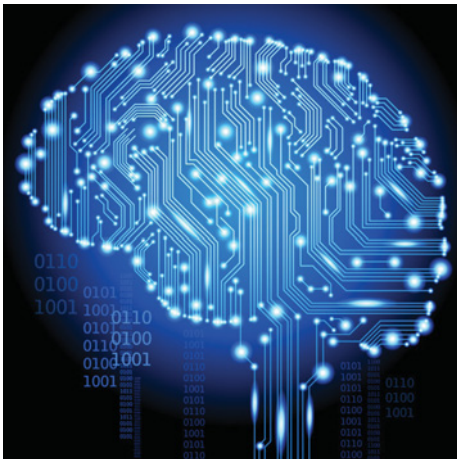

Artificial Intelligence in Asia: Preparedness and Resilience

Asia Business Council

Artificial Intelligence in Asia: Preparedness and Resilience

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EXECUTIVE SUMMARY

Artificial Intelligence, commonly known as AI, has begun to transform businesses, jobs, and economies. Machines are increasingly able to perform tasks that only humans could do previously—often more quickly and accurately, too. Significantly, they are also starting to generate results or insights by themselves when given access to data, without being explicitly programmed. AI presents an enormous opportunity—those economies that can use AI to help with growth will improve economic competitiveness, capture value in multiple industries, and transform the lives and habits of millions and billions of people.

For developed Asian economies, the investment-led, labor- and resource-intensive growth model that fueled the "Asian miracle" of the past several decades is becoming obsolete. Slowing growth, aging demographics, and rising levels of wealth disparity all point to the need for new drivers of growth and productivity. For large developing Asian economies, including China, India, and Indonesia, the need to move away from growth driven by cheap labor and energy and the vast opportunity to serve a growing consumer class mean they could benefit greatly from a different growth path. Overall, AI offers opportunities for Asian economies to transition to a knowledge-intensive and high-productivity growth model. This briefing analyzes the extent to which Asian economies are prepared for the AI-led revolution, and the extent to which governments and societies are resilient to the potential economic and social changes and disruptions brought about by AI.

In the past decade, AI has gone from science fiction to reality. Google began to develop a driverless car in 2009. IBM's natural language computer Watson defeated two *Jeopardy!* game show champions in 2011. The Google Brain neural network simulator used a learning algorithm to recognize images of cats without being given identifying information in 2012. Google DeepMind's AlphaGo computer program defeated the human champion in the game of Go in 2016. In 2017, Google DeepMind's AI taught itself to walk, run, and jump.[1] The ability of AI to substitute, compete with, and enhance human activities keeps accelerating and broadening to different sectors of business and society.

Driven largely by private technology companies, Asia is experiencing huge AI growth due to the large volume and broad range of data generated by hundreds of millions of users of the mobile Internet and various apps, coupled with a rapid increase in investments targeted toward AI development. The *Economist* recently referred to China as the "Saudi Arabia of Data," referring to China's 730 million Internet users, the largest for any country in the world and equivalent to almost the entire population of Europe.[2] The huge amount of data enables AI systems to generate more sophisticated insights, helping businesses save costs, scale operations, improve productivity, and offer more targeted products and services to consumers.

Government leaders throughout Asia not only have to prepare for a future where AI dominates business and the economy, but also a future where AI changes the nature of human work, both creating new opportunities and disrupting current employment structures.

The Asia Business Council developed an Asian Index of Artificial Intelligence (AI^2) to analyze the preparedness and resilience of eight Asian economies with respect to an AI-led future for their economies and societies. Preparedness measures the extent to which companies and talent can capitalize on AI opportunities, while resilience measures the extent to which governments and societies can adapt to and withstand broader structural changes resulting from AI use. Index results showed that out of the eight economies analyzed, China topped the overall ranking with a big lead. Singapore and India followed. Japan, Taiwan, and South Korea ranked in the middle, and Hong Kong and Indonesia ranked relatively low overall.

Asia is at the beginning stages of an AI revolution. Surviving and thriving in an AI age requires transformative business practices and policies. A new generation may lead this growth, but the existing business leaders and policymakers who bring experience in running companies and making policies must change and adjust to this new force now, to ensure that AI will be a driver of positive change in their economies and societies in the future. Asia also needs to overcome significant challenges that AI could bring, ranging from job destruction to invasion of privacy. Those economies that are prepared and resilient will reap enormous gains in growth and progress in the global digital economy, while those that are not risk being left behind.

THE RISE OF ARTIFICIAL INTELLIGENCE

Tasks performed by AI can include translating languages, recognizing faces in photos, recognizing speech in audio clips, and sensing distances of vehicles. The rapid increase in computing power and data, and increasingly powerful analytics have accelerated machines' ability to perform increasingly more complex tasks with higher precision. A key development in the AI field is machine learning, where computers construct algorithms that can find patterns and make predictions from complex data without being explicitly programmed or "taught" by humans.[3] A powerful sub-branch of machine learning is deep learning, whereby the computer mimics human neural networks, running data input through multiple layers of concepts and "learning" from successive data layers.

While technology companies have been the predominant force in developing AI technologies so far, other sectors such as financial, retail, education, transportation, law, and healthcare firms are building in-house capabilities in AI. Depending on the state of a company's infrastructure, introducing these technologies may require sizeable investments, high levels of adaptability, time, and talent, especially if companies are to integrate them into core processes—but the benefits will be significant in terms of creating new value and lowering costs.

For example, some financial companies have adopted AI-based systems to execute stock purchases and answer investor questions.[4] Others are using AI to determine the creditworthiness of customers based on personal spending history and even friends' credit scores.[5] E-commerce companies are actively using AI to help create personalized product search results and chatbots to solve customer issues.[6] Robot helpers interacting with students are starting to transform traditional classroom environments.[7] In transportation, AI is continuing to grow in application with a projected 10 million cars with self-driving features expected to be on the road by 2020.[8] Legal robots are being used in China to review cases, many of which are traffic violations, and to advise appropriate sentences.[9]

Healthcare is one of the industries in which AI can have a substantial positive impact. A recent McKinsey report contemplates a future in which learnings from analysis of the behavioral, genetic, and molecular data connected with many patients can be used to treat individual patients more effectively and yield tril-

lions of dollars in savings for the U.S. healthcare industry.[10] AI can interpret data from doctors' reports, test results, and medical images to improve treatment.[11] For example, AI can analyze and learn the latest oncology research from all relevant journal articles, and come up with individualized cancer treatment plans based on clinical data and medical history of patients.[12] AI is also used to analyze genomic data to identify specific gene mutations that cause disease, so as to develop drugs that specifically target the errant genes.[13]

The ways in which AI technology is being used vary by industry, but what remains consistent is how profoundly it is transforming business capacity and efficiency. And while AI-driven systems and products can accomplish mostly specialized tasks today, in the future they are expected to have the ability to work on more generalized tasks and across domains.[14]

Within Asia, Chinese companies are frontrunners in the global race to adopt AI. Different AI technologies, including robots, and voice and image recognition are experiencing rapid growth, led by technology giants in the private sector. Over the next decade, China plans to play a leading role, utilizing the strengths of its existing businesses and through a new government plan, announced in July 2017, by China's State Council. The plan's goal is for China to be a world leader by 2030 in areas such as self-driving cars, "smart" robots (that can learn from their environment and build on their capabilities based on that knowledge), virtual reality, and military applications. It centers upon developing products and markets in these areas, creating open-source computing platforms for AI, as well as training professionals and scientists.[15]

ASIAN INDEX OF ARTIFICIAL INTELLIGENCE (AI²)

Some Asian economies are more prepared for an AI-driven economy than others; economies also differ in terms of the resilience of governments and societies to changes brought about by AI. The Asia Business Council developed a framework Asian Index of Artificial Intelligence (AI²) to better understand where Asian economies stand in terms of their preparedness for and resilience to AI-led changes. The index analyzed four Asian economies (China, India, Japan, and Indonesia), selected for their large populations and number of Internet users, and the four Asian Tiger economies (Hong Kong, Singapore, South Korea, and Taiwan), selected for their high level of economic development and technological adoption in recent decades.

The index analyzed developments across Asia by finding comparable data for the selected Asian economies on a range of relevant indicators that contribute to AI preparedness and resilience.[16] Overall, China emerged as the economy in Asia with the highest composite index score. Singapore and India follow, with Japan and Taiwan not far behind (see Figure 1). Looking at sub-indices of preparedness and resilience separately further provides a nuanced view of relative areas of strength and weakness.

AI PREPAREDNESS

To understand AI preparedness of economies, which is the ability of companies and talent to capitalize on opportunities brought about by AI, four key dimensions were analyzed, including the prevalence of overall startup activity, venture capital raised by top AI startups, students enrolled in science, technology, engineering, and mathematics (STEM) subjects at top-ranked universities, and AI publication volume. China outpaces other Asian economies in most of the dimensions (see Figure 2).

Startup activity is measured by the number of tech startups in each economy that have received venture funding and those that have been acquired. Among the eight Asian economies, India has the most startups, with China a close second. Together they remain far behind the U.S., which has more than 10 times the number of tech startups. Taiwan, Japan, and Singapore lag further behind but each have similar numbers of startups.

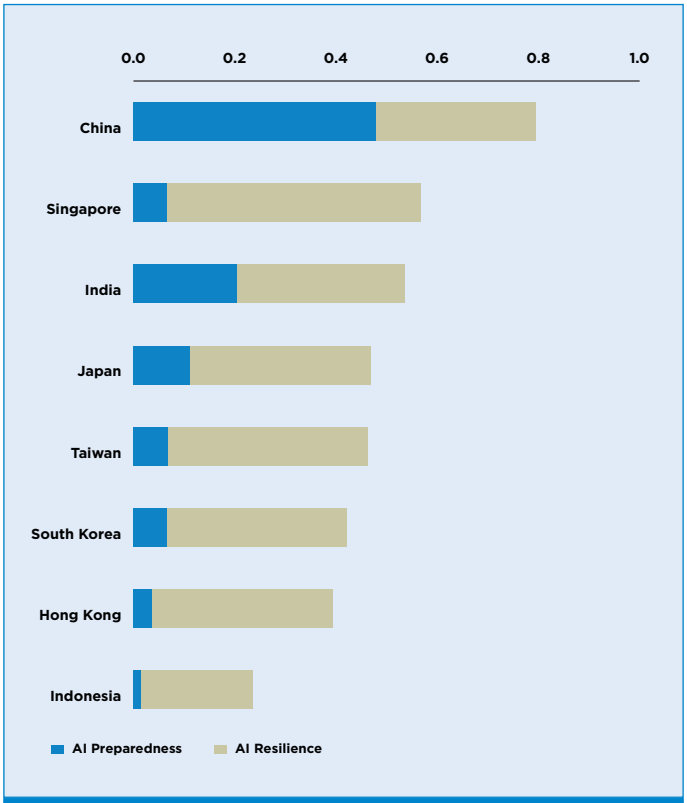

FIGURE 1
ASIAN INDEX OF ARTIFICIAL INTELLIGENCE (AI²) 2017

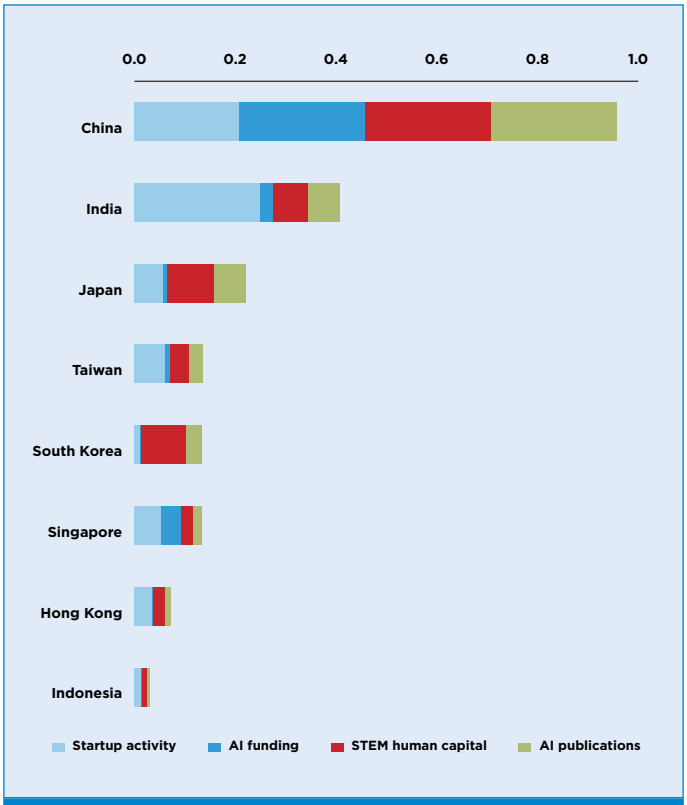

FIGURE 2
AI PREPAREDNESS SUB-INDEX

Looking specifically at startups focused on AI, as measured by the amount of publicly disclosed equity funding for startups describing their business as focused on artificial intelligence, machine learning, or deep learning that ranked among the top 5,000 startup companies in Crunchbase, an online database that tracks startup size and activity around the world, China leads by far in total equity funding, reaching $1.2 billion as of July 2017. In addition, Singapore is a bright spot, ranking second only to China, though with far fewer startups. In South Korea, both the number of tech startups and AI venture funding are small relative to economy size, which may reflect the fact that AI-focused investments and innovation take place largely within chaebol companies. A similar pattern is found in Japan, which raised less AI startup funding than Taiwan, despite being a much larger economy. By contrast, Hong Kong and Indonesia lag in terms of AI equity funding. Another analysis by Chinese think tank Wuzhen Institute estimated that the U.S. topped private investments in AI, with almost US$18 billion, accounting for about three-quarters of total private sector funding raised from the first quarter of 2012 to the second quarter of 2016. This shows that Asia as a whole still lags behind the U.S. in equity funding for AI startups.[17]

University students studying STEM, who could become tech sector workers and entrepreneurs, provide a useful proxy for human capital present and future. As a way of screening for the quality of educated talent, the index analyzed the number of enrolled undergraduate and graduate students only at universities in each economy that ranked among the top 500 universities in the world. China has more than 20 of these top-ranked universities, whereas the U.S. has more than 90. Due in part to the university screening, our estimates show that the U.S.'s STEM university student

enrollment exceeds China's by about 300,000. However, the larger-on-average share of students at Chinese universities choosing STEM subjects means China will quickly catch up in absolute numbers if current trends continue. An additional factor is that China sends a large number of international students abroad to obtain higher degrees. Already, international students, the largest share of whom are Chinese, Indian, and South Korean, comprise more than half of the graduate students earning master's and doctoral degrees in STEM subjects in the U.S., although they only account for about a tenth of all graduate students.[18] The race for talent will be influenced as well by visa and immigration policies, which will in part determine which economies will assimilate the educated Asian STEM workers into their domestic workforces. By contrast, Hong Kong and Indonesia have relatively smaller proportions of students in top universities studying STEM subjects.

Finally, the quality of innovation in AI is measured by the quantity of citable documents on the topic of AI in Scopus, the world's largest database of peer-reviewed scientific publications including articles, reviews, and conference papers. China already leads with more than 25,000 citable documents between 2014 and 2016, well ahead of the U.S.'s 18,000. The caveat is China's quality of publications lags that of the U.S. and other Asian economies in terms of citation impact, an oft-used measure of publication quality. Only counting individual institutions that published more than 500 times on AI and ranked by citation impact, the U.S. leads with almost 3,000 AI papers, followed by Singapore's 2,000, Hong Kong's about 1,100, and China's almost 600.[19] Despite their smaller populations, significant contributions to AI research are being made by Singapore and Hong Kong's higher education institutions. This is further confirmed by the relatively high number of top 1,000 computer scientists in the two small economies.[20]

AI RESILIENCE

To understand the resilience of various economies, which is their ability to adapt to and withstand broader structural changes brought about by AI, we looked at several indicative government policies related to AI and also the employment structure of economies, specifically the share of middle-skilled work that is vulnerable to AI disruption. The overall sub-index shows that Singapore, Taiwan, Hong Kong, Japan, and South Korea are among the more resilient economies to AI-induced changes. But the picture is more nuanced—China, which has proactive government policies to advance AI, has a more vulnerable overall employment structure. By contrast, India, which has less concrete policies, has an employment structure that is less prone to immediate AI disruption (see Figure 3).

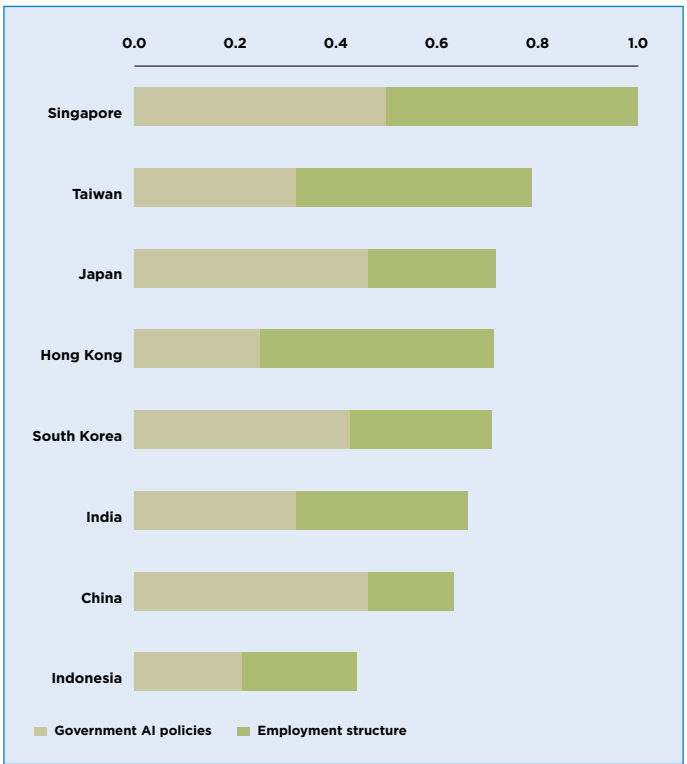

FIGURE 3
AI RESILIENCE SUB-INDEX

Government policy areas analyzed included data openness, AI-related tax credits and/or subsidies, and government funding for AI development. We also looked at policies targeted at job displacement, social safety nets, and legal responsibility of AI systems. To illustrate the level of resilience of each economy, we established a composite score of these policies, where each economy was ranked as having a low, medium, or high

level of resilience based on existing policies. Singapore showed the most proactive government policies overall, with Japan and China close behind it. South Korea led the medium group; Taiwan, India, Hong Kong, and Indonesia were ranked relatively low.

Easily accessible and machine-readable data, or open data, is essential for governments and businesses planning to expand opportunities in AI in their economies. According to a McKinsey study, almost US$3 trillion in economic potential could be untapped from increased use of open data, which help bridge information gaps across sectors and improve analytics when combined with proprietary data.[21] To assess data openness, we compiled data from the Global Open Data Index and the Open Data Barometer, which rank economies overall and by detailed categories, such as machine-readability. Most of the Asian economies we assessed had high levels of data openness, but China and Indonesia both fell short as much of their government data is inaccessible or not easily readable by machines.[22]

Existing government tax incentives and subsidies were analyzed to provide a greater understanding of how governments are encouraging entrepreneurship and development related to AI. China is taking the lead in this category. China's incentives are not only coming from the national level but from the local level as well; billions of dollars are being spent in cities, such as Suzhou, Shenzhen, and Xiangtan, to encourage further development in robotics and the establishment of AI projects in these cities.[23] Singapore's government is subsidizing the development and testing of social robots, such as office receptionists, hospital assistants, and pre-school teachers.[24] The Japanese government broadened an existing tax credit for R&D investments related to the service sector to help bolster productivity through AI, including it in the fiscal 2017 tax code.[25] Hong Kong's Secretary for Innovation and Technology announced a plan this January to offer financial and tax incentives to attract technology enterprises, especially those specializing in Big Data, Internet of Things, and AI, though details remain sparse.[26]

Evaluating the level of government support and funding for AI research and startups is also a valuable proxy for AI-enabling government policies. In this category, we ranked economies by the expansiveness and level of investment in research initiatives and found that China and Singapore both lead in this area. The Chinese government's plans for a national engineering lab headed by Chinese technology giant Baidu focused on researching deep learning technologies were approved earlier this year.[27] Singapore's core initiative AI.SG has a goal of integrating universities, investors, startups, institutes, and industry leaders to catalyze the advancement of AI research.[28] Its "Smart Nation" initiative plans to digitalize money, create new digital IDs for citizens to better protect online identities and prevent fraud, and use a sensor system to help predict traffic congestion and manage crowds.[29] Japan, South Korea, and Taiwan also have high levels of government-funded research, with all three governments funding a number of public-private initiatives. For example, in the first budget released since President Moon Jae-in took office in May 2017, government spending on R&D next year is projected to be 19.6 trillion won (US$17.8 billion), roughly 6 trillion won of which is set aside for AI, Internet of Things (IoT) and autonomous vehicles. The government says this investment will bolster South Korea's ability to compete in the Fourth Industrial Revolution.[30] Hong Kong officials have openly discussed the need for innovation, including attracting businesses using AI, as well as announced initial plans for a joint innovation and technology park in collaboration with neighboring Shenzhen. Indonesia's Ministry of Communications and Informatics has laid out a vision for Indonesia to become the "Digital Energy of Asia," which aims to digitally equip 1,000 companies by 2020, though there are many challenges as Indonesia's small- and middle-sized businesses do not yet have a digital presence.[31] For this reason, Indonesia, in addition to India, was ranked as relatively low-preforming in this category.

As AI becomes more advanced and increasingly visible, governments will need to rework legal frameworks to involve new laws that regulate robots and other AI-driven systems. As of now, Japan has the most in-depth legal strategy out of the selected economies to confront the increasing presence of robots, called "Japan's New Robot Strategy," published in 2015. This strategy outlines everything from

Japan's current status as a robotics superpower to a five-year plan that addresses policies on the global standardization of robotics, the establishment of a "Robot Revolution Initiative," and the implementation of robot regulatory reform, among other areas.[32] Furthermore, Japan also plans to develop a new legal framework, which will protect individual and business copyrights for creative assets made by AI.[33] In South Korea, government officials have stated plans to establish legal and ethical standards, such as those addressing accountability in cases of AI-related accidents.[34] In December 2016, the government unveiled its "Mid-to-Long-Term Master Plan in Preparation for the Intelligent Information Society, Managing the Fourth Industrial Revolution," which states the need for policymakers to work towards creating a regulatory regime that addresses how to deal with new technologies not addressed in the current legal system.[35] In 2016, China's State Standardization Administration set a timeline for the publishing of national regulatory standards for the robot industry, with the first 30 standards to be finalized in 2018, and twice as many additional standards to be written into law by 2020.[36] Singapore did not perform as well in this category, as it has yet to establish policies targeted at AI-related legal changes, though it has sought to update transport laws to increase safety for users of autonomous vehicles.[37] Taiwan, India, Hong Kong, and Indonesia have yet to make progress in the AI-related legal arena.

Governments are also under pressure to identify ways to cushion the potential workforce impact of AI. Among the economies analyzed, Singapore leads the way in policy formulation with its SkillsFuture initiative, which focuses on workforce retraining. Starting from January 2016, every Singaporean over the age of 25 has been given a US$345 credit for training courses by 500 approved providers. Older workers above 40 are eligible for training subsidies in addition to this credit.[38] The initiative seeks to integrate the voices of different groups, including a variety of industries, unions, and educational institutions. Efforts by the Ministry of Education in China center on increasing the number of AI-related vocational degree programs in the country, such as programs titled "Industrial Robots Technologies," resulting in more than 300 vocational institutes solely centered on robotics technologies having been established by August of 2016.[39] Japan has set forth a strategy outlining its "Future Vision towards 2030s" that addresses structural employment changes driven by AI, while South Korea's Ministry of Employment and Labor has established a project "to develop human resources leading the fourth industrial revolution."[40] Notably, South Korea recently established the first indirect Robot Tax, which revealed plans to decrease the number of tax benefits previously allotted to enterprises for increasing productivity.[41] This is a clear sign that South Korean officials are taking steps to slow down the automation of jobs. Among the lower-performing economies in thinking about how to prepare workers for the AI revolution are Hong Kong, Taiwan, Indonesia, and India. Indonesia and India are attempting to advance worker skills, especially India, with policy initiatives like Skill India, but these efforts fall short of addressing the advanced skills necessary for imminent AI labor disruptions.

Finally, we considered government policies that address the need for social safety nets as a result of potential job disruptions that come with an AI revolution, especially for those workers whose jobs are lost to automation. The possible implementation of a universal basic income (UBI) in various forms has been discussed in many countries, though there is no consensus yet on its feasibility and effectiveness. Nonetheless, governments faced with the potential reality that a large share of the workforce may eventually not contribute to society in the form of paid work are under pressure to come up with policy solutions. No economy was ranked as high-performing in this category, and those who were ranked in the middle were largely ranked as such because the topic of a universal basic income or a similar system have garnered significant public attention, or because pilot programs have shown success. Government officials in India have experienced such success in previous UBI pilot programs, and a top Indian economist, Arvind Subramanian, has made his enthusiasm for UBI well-known.[42] China's Dibao system, a system of basic income, has been in effect since 2007. While this system has been criticized for endemic corrupt practices and inefficiencies, it has also been commended by the World Bank for helping decrease poverty by 6.5% since its start.[43] What is interesting to note is that except for

Indonesia, all the other governments have discussed UBI or a similar system to some degree, signaling growing concerns and desires to find a solution to structural shifts affecting workers. In fact, UBI has become a prominent subject in South Korean politics, especially since well-known politicians commended a project called the "youth dividend" in Seongnam city, which gives US$230 each quarter to everyone aged 19-24 who have lived in the city for three years or more.[44] National policy conversations around UBI in Asia are increasing in number and urgency.

The other key measure of the resilience of economies to AI disruption is the underlying employment structure of Asian economies, specifically the share of jobs with work activities that are not easily or immediately replaced by AI. While AI can generate large economic value for companies and economies, it has prompted a vigorous public debate in the U.S. and Europe on whether broader use of AI will destroy jobs and hasten economic dislocation and inequality, creating a new "digital divide" between those with skills that make them employable in the digital economy and those who lack them.

According to McKinsey & Co., the jobs that are at highest risk of disruption by AI are medium-skill jobs, particularly those in which work activities are routine and predictable. In 2016, McKinsey estimated that 51% of jobs in China can be eventually automated, affecting more than 390 million full-time employees, amounting to more than the whole U.S. population. China is particularly vulnerable to AI disruption, given its large share of medium-skill manufacturing and service jobs that involve a large proportion of routine and predictable tasks, though this may coincidentally be coming at a good time as China may face a labor shortage due to aging demographics. More than 230 million people would be affected in India and 36 million in Japan.[45] A study by Nomura Research Institute in 2015, analyzing 600 occupations, predicted that 50% of jobs in Japan could be done by robots by 2035.[46] Professors Frank Levy from Harvard University, and Robert Murnane from MIT, pointed out that policymakers in the U.S. should be most concerned about jobs in the middle-skill category such as assembly-line and clerical workers. Many rules-based jobs, with defined standard operating procedures, have already been offshored to lower-cost economies since the mid-1980s, mostly to Asian economies like China and India, leading to downward mobility of workers, hollowing out the middle class and widening inequality. AI could exacerbate this process. The education system must shift its focus to building more complex foundational skills including conceptual understanding and problem-solving, rather than procedural skills to follow rules and routines that can be automated.

Schooling in Asia seems to lag behind—the idea that people are empty vessels into which facts are poured still predominates. However, jobs that entail non-routine, unstructured work and problem-solving, like those of nurses and other healthcare support workers and auto mechanics, may be more resilient to automation.[47] Additionally, and perhaps counterintuitively, AI can even supplant people in what have traditionally been perceived as high-skill jobs. J.P. Morgan's Contract Intelligence or COIN program, which uses AI to interpret commercial loan agreements, can do in several seconds what used to take lawyers and loan officers 360,000 hours of work each year.[48] Such technology may threaten employment in trade and finance, on which Hong Kong and Singapore are dependent. In China, machine translation of dozens of languages into Chinese is expected to decrease demand for human translators. The Google Ventures-funded Kensho machine learning system that analyzes the impact of world events like Brexit on asset prices has been widely adopted by trading desks at major banks, delivering new insights to clients while reducing the need for human analysts.[49]

The scale of job destruction due to AI also depends largely on how AI is designed, how governments prepare workers for the transition and its effect on wealth distribution. In a more positive scenario, AI could free people for more value-added, productive, and creative work. In a richer world enhanced by "smart" machines, doctors might spend more time caring for patients and academics could do more productive research. AI could also reduce costs and increase convenience for consumers.

The promise of an AI-infused "near future" also brings with it many ethical and political questions, spanning privacy issues—both personal and data, press freedom, and also cybersecurity and national security, to name a few. For example, facial recognition software could be used to infringe upon privacy or profile individuals without consent, for purposes of discrimination. The potential use of autonomous weaponry that could cause large-scale damage and human suffering is another area that has been the subject of vigorous debate.[50] While these topics are beyond the scope of this briefing, they require serious consideration by designers, regulators, and other leaders of AI development. China is often the stand-in for some of the fears that humans have as AI capabilities become more powerful. The Chinese government can block politically sensitive images as well as enlist private companies like Baidu and Alibaba to open their research labs to the state, and it is developing a "social-credit" system that scores people based on metrics including "filial piety." The *Economist* observed that "Western companies are at least engaged in an open debate about the ethical implications of AI; and intelligence agencies are constrained by democratic institutions."[51] But debates over ethical questions brought about by AI, as well as the role of business and government in addressing them, have only begun to emerge in the public realm in much of Asia.

CONCLUSION: THE WAY FORWARD: EMBRACE AND ADAPT

Companies and governments around Asia must act on a number of key priorities to become more prepared for and resilient to AI-led changes. They must train new workers and retrain existing ones to work alongside machines, unleashing new productivity that can benefit consumers and societies. Businesses should think about what they can do to help alleviate the negative effects of job destruction, so more people can share the gains generated from growth. More thoughtful economic and social policies by governments can encourage AI design to be beneficial to humans and ease the painful transition for workers and families whose livelihoods may otherwise be disrupted. Education and vocational training institutes need to prepare those at different skill levels to perform work functions that computers cannot do. The next generation of workers and entrepreneurs must be equipped with skills that enable them to work with and manage computers and intelligent systems, solve problems that are non-routine and unpredictable, and learn to understand and interpret more complex data.

AI technology presents both a great opportunity and challenge to businesses and policymakers around Asia. Initially, the temptation may be to turn back the tide or do nothing. Ultimately, given the transformative power of this technology, there is little choice but to embrace and adapt. The key goal is to make humans the beneficiaries, not the victims, of AI technology. In doing so, Asia will be better-positioned to tap into this new source of growth, productivity, and prosperity for the region.

ADDITIONAL INFORMATION AND REFERENCES

GLOSSARY: BASIC DEFINITIONS OF KEY AI TERMS IN BRIEFING

Term	Definition
Artificial Intelligence	The science and engineering of giving machines, particularly computer programs, the ability to perform tasks requiring human levels of intelligence.[52]
Machine Learning	The process by which computers construct algorithms, or a sequence of well-defined instructions, that can automatically find patterns and make predictions from data, and improve from experience, without being explicitly programmed or "taught" by humans.[53]
Deep Learning	A form of machine learning in which computers mimic human neural networks, running data input through multiple layers of concepts, "learning" from successive data layers, in order to recognize patterns in sounds, images, and other data in digital form.[54]
Speech Recognition	The ability of computers to identify and convert the words in spoken language into a format that is machine-readable.[55]
Natural Language Processing	The ability of computer algorithms to analyze, understand, and generate human language.[56]
Computer Vision	The ability of computer algorithms to recognize, categorize, and distinguish objects and useful information automatically from a single image or a sequence of images.[57]
Internet of Things	A network of connected "things" (which also includes people) resulting from the connection of devices that can be turned on or off to the Internet.[58]

AI² INDICATOR DESCRIPTION AND DATA SOURCES

Dimension	Indicator by Economy	Weighting	Data Source(s)
AI Preparedness		50%	
Startup activity	Number of startups in Crunchbase database that have disclosed total funding of at least US$1,000, plus startups that have been acquired for at least US$1,000	12.5%	Crunchbase database, July 2017
AI funding	Total disclosed equity funding of AI companies in top 5,000 of Crunchbase database that have the terms "artificial intelligence," "machine learning," and/or "deep learning" in business description	12.5%	Crunchbase database, July 2017
STEM human capital	Estimated number of graduate and undergraduate students enrolled in STEM subjects at QS Top 500 universities	12.5%	QS World University Rankings 2017, National Science Foundation
AI publications	Citable documents in the discipline of AI (including articles, reviews, and conference papers), 2014-2016	12.5%	SCImago Journal & Country Rank public portal (developed from the information contained in the Scopus® database), July 2017

AI² Indicator Description and Data Sources continued

Dimension	Indicator by Economy	Weighting	Data Source(s)
AI Resilience		50%	
Government AI policies		25%	
Data openness	**Low**: none or most government info is not machine readable/the data doesn't exist **Medium**: some of the data is machine-readable/some of the data exists **High**: most data is machine readable/the data is there		The World Wide Web Foundation Open Data Barometer 2017; Global Open Data Index 2016/2017
Tax credits, subsidies	**Low**: none or slowly emerging discussion **Medium**: proposals about or early implementation of AI tax incentives or subsidies **High**: major tax credits/subsidies directly relevant to AI		Various news sources and government websites, 2017
Government support of AI research and startups	**Low**: none or slowly emerging discussion, no specific discussion of AI **Medium**: some discussion of AI support and funding **High**: concrete policies and funding directly supporting AI research and startups		Various news sources and government websites, 2017
AI legal changes	**Low**: no discussion **Medium**: emerging discussions on national level **High**: complete policy proposals, already established AI-related regulatory practices		Various news sources and government websites, 2017
Job retraining programs	**Low**: no programs or emerging discussion **Medium**: clear policy proposals addressing the matter, clear timeline on expected implementation **High**: effective job training programs currently in progress, directly address AI skill needs		Various news sources and government websites, 2017
Social safety net	**Low**: no discussion **Medium**: emerging discussions on national level **High**: successful pilot programs, existing attempts at some kind of basic income provision		Various news sources and government websites, 2017
Employment structure	Percentage of jobs as a share of national employment that are not immediately vulnerable to AI disruption; specifically, jobs that are not in "Skill level 2" or "medium-skilled" job categories as defined by the ILO, which include clerical support workers, service and sales workers, plant and machine operators, and assemblers	25%	International Labour Organization (ILO) database of labour statistics, 2017

PRIVATE SECTOR AI DEVELOPMENT IN ASIA: SELECTED COMPANY EXAMPLES BY ECONOMY

CHINA

Large Chinese technology companies are honing their algorithms across all AI applications, including speech and image recognition, digital assistants, ad targeting, financial underwriting, and AI cloud. They already pose a credible threat to U.S.-based competitors like Amazon, Facebook, Google with its now-famous AI program DeepMind, and IBM, known for Watson, within China's borders, though it remains to be seen if they will be able to expand beyond them.

With more than 500 million mobile active users monthly on its B2C site, Tmall.com and C2C site, Taobao Marketplace, Alibaba sits at the center of its own constantly refreshed pool of data garnered

from customer transactions.[59] This information on customer purchasing behavior, payment and credit history, demographics, social networks, personal interests, and other areas provides content and context for training its algorithms.

Alibaba employs AI for large-scale commercial use, including personalized search and "intelligent customer service" with Ali Xiaomi, a chatbot that uses AI voice recognition and neural networking to solve customer problems. The bot's capabilities are constantly improving, and can now handle up to 95% of customer enquiries, appreciably reducing the need for human customer service staff.[60] Alibaba rolled out Dian Xiaomi (Store Assistant), a text-only chatbot, for its customers in Taobao and Tmall. It also offers merchants on Taobao and Tmall AI-assisted storefront design.[61]

Alibaba is a Chinese first-mover in AI cloud. Its "Apsara" cloud platform controls about 40% of the Chinese market, ranking among the largest cloud providers globally.[62] Apsara not only powers internal applications like Ali Xiaomi and Dian Xiaomi; it also offers a suite of cloud services to Alibaba customers that can process, analyze, and store huge amounts of data. Alibaba's computational engine can process more than 175,000 transactions per second.[63]

Tencent, with 963 million monthly active users of Weibo and Weixin compared to Facebook's 2 billion monthly active users, is China's social media and gaming giant.[64] The company views AI as a long-term strategic initiative. On a recent earnings call, Tencent highlighted ongoing investments in machine learning, computer vision, speech recognition, and natural language processing. It is applying AI throughout its Internet finance businesses, including mobile payments, wealth management, and microloans. Data collected from users can more precisely predict potential borrowers' behavior.[65]

As China's dominant search engine, Baidu is a global leader in AI applications, among them speech recognition and computer vision. Baidu's Deep Speech 2 algorithm is often capable of recognizing Mandarin and English better than humans. This is important in China where there are many regional dialects of spoken Mandarin and where the typing of Chinese characters can be complex. Baidu Brain and its Institute of Deep Learning rivals Google's DeepMind. PaddlePaddle, its deep learning platform, is offered free to developers and is "open source," as are similar offerings from U.S. tech giants Microsoft, Facebook and Amazon, and Google.[66] Open-source tools allow for ease of collaboration across a range of applications, including speech and image recognition and driverless cars.[67]

Baidu also recently unveiled its Apollo autonomous vehicle program, in which it is partnering with 50 other companies, including NVIDIA.[68] In July 2017, NVIDIA CEO Robert Li live-streamed his ride from an Apollo car traveling at speed on Beijing's third ring road, to an AI developer conference.[69] Apollo cars will be available to the public in 2019. The field is crowded, as Uber, Volkswagen, BMW, Ford, and other traditional car makers, as well as Google, plan to introduce self-driving cars.[70]

Lenovo has announced a US$1.2 billion investment in AI research and development. The PC, mobile phone, and tablet maker is extending its traditionally hardware-focused brands to include "smart solutions and partnerships in the manufacturing, healthcare, and transportation sectors."[71] Lenovo showcased several concept products including Xiaole, an AI customer service platform for businesses; daystAR, an "augmented reality" headset for video games, in partnership with Google; the CAVA, a virtual assistant that uses facial recognition to manage calendar events, and SmartVest, a shirt made of high-tech fabric that monitors the wearer's heart rate.[72]

Aside from the big players, Chinese startups run a gamut of specialties. Earlier this year, SenseTime Group Ltd., a deep learning and computer vision developer, broke the record for AI fundraising in a private round, raising US$410 million, much of it from entities backed by the Chinese state.[73] Another startup is Mobvoi, offering voice search technology for conversational chatbots.[74] iCarbonX, an "individual health steward" founded by Chinese geneticist Jun Wang, former CEO of biotechnology firm BGI, aims to guide users to best health outcomes based on a combination of their own data and "big data"

analytics.[75] Wecash, an AI loan underwriting engine, gives Chinese pig farmers access to lower borrowing rates to buy food for their herds.[76] Toutiao, a news app, uses AI to "curate" personalized news feeds designed for phone viewing and even has an artificial reporter called Xiaoming that can write news articles on European soccer games. Toutiao is one of the top mobile apps in China, with 700 million users.[77]

SINGAPORE

Singapore punches above its weight in terms of new AI dollars committed, but, given its small size, remains well behind China in terms of private sector developments. Singapore's most significant push for AI is the government initiative mentioned above, AI.SG, that will commit US$107 million of funding to AI over the next five years to encourage collaboration among and between AI inventors, academics, startups, and government agencies for projects like improving traffic flow and the healthcare system.[78]

Several Singaporean startups have garnered significant investor interest. Trax is a computer vision company geared toward retail shelf inventory reporting, using photos of retail store shelves taken by a mobile phone or tablet to relay product information to consumer product companies like current Trax customers Coca-Cola, Nestle, and AB InBev. Typically, companies pay retailers for shelf space and shelf placement (at customer eye level, endcaps, promotions, etc.). Confirming accurate details of shelf space arrangements has typically required teams of auditors sent from the brand. Trax tallies inventory and confirms product placement, pricing and promotions. It compiles a report and relays it to brand managers, reducing employee time spent on inventory by 60%.[79]

Near, another Singaporean startup, provides insights into customers' shopping and spending habits, using AI to process location data from clusters of smartphones, known as "ambient intelligence." The Near platform powers Allspark, its flagship SaaS product, which allows advertisers and brand managers to parse ambient data in a variety of ways. Examples include analyzing demographics and spending trends in a given area to plan media spend, and using data to plan capital expenditures and build new stores where they will have the most profitable foot traffic.[80]

INDIA

Due to India's vast linguistic diversity, most research efforts have focused on machine translation, natural language, and text-and speech-related applications.[81] Many top startups have developed applications for the consumer retail sector, including Ratan Tata-backed Niki.ai, a conversational interface, or chatbot, that shops for consumer products and services and places orders with partner businesses.[82] Manthan provides data analytics and business intelligence for retail companies and marketers.[83]

Indian AI in financial services is a promising area, as underserved consumers can be underwritten based on smartphone-generated data. New consumer lending platforms (some of which employ AI) are being built to interact with Aadhaar, India's biometric identity system, which is a great help with increasingly stringent "know your customer" regulations, designed to cut down money-laundering and other illegal transactions.[84] Arya.ai and others are beginning to make their mark domestically, as fintech startups are often able to underwrite loans more efficiently than incumbent players (or screen insurance risks). Collaboration with incumbents is a natural win-win, as start-ups lack big balance sheets but offer nimbler front-end origination capabilities to incumbent banks who have capital to make loans.

Privately funded research in AI in India is notably still nascent, with the exception of the Infosys Center for Artificial Intelligence. Located at the Indraprastha Institute of Information Technology, Delhi, it conducts both fundamental and applied research on robotics, machine learning, and computer vision, and built and tested a driverless golf cart at the Infosys Mysuru campus this year.[85]

JAPAN

Japan lags behind China and India in terms of private-sector efforts in developing AI, but has recently announced a government plan to build the world's fastest supercomputer to help spark deep learning research.[86] China currently holds the record for the world's fastest and second-fastest computers.[87]

Japanese companies are building on their skills in high-tech manufacturing to focus on robotics and IoT. Japanese conglomerates Toyota and Hitachi have both set up R&D facilities in the U.S.

In 2016, Toyota formed Toyota Research Institute (TRI) in several locations in the U.S.[88] It plans to invest US$1 billion over five years, focusing on robotics for home and business use, and on AI for improved safety in both traditional and autonomous vehicles.[89] TRI allocated US$100 million to Toyota AI Ventures, its venture capital subsidiary, specifically for the cultivation of startup companies in AI, robotics, autonomous mobility, and data and cloud technology.[90]

Last year, Hitachi located the Hitachi Insight Group, a team of 6,000, in Silicon Valley, California. The group will focus on Lumada, Hitachi's IoT platform that collects information from sensor-embedded products Hitachi manufactures and sells to key end-markets, like those for public safety and smart cities. This information, processed by AI, helps systems run more efficiently, safely, and at lower cost.[91]

One Japanese startup stands out as a favorite partner for collaboration: Preferred Networks, a deep learning company specializing in the IoT. Toyota bought a 3% stake in it in 2015. Fanuc, the Japanese company that is the world's largest maker of industrial robots, invested as well, with the goal that its robots can learn skills independently, much like Google's DeepMind teaching itself how to walk, run, and jump.[92]

TAIWAN

Taiwanese technology companies are competing in AI through building on their manufacturing capabilities to develop hardware and tools that make AI faster and more powerful. For instance, powerhouse chipmaker Taiwan Semiconductor Manufacturing Company (TSMC) is building on its strength as a leading semiconductor manufacturer to build advanced data center graphics processing units (GPUs), in partnership with NVIDIA.[93] GPUs can process more data, more quickly and flexibly than the older generation of central processing unit (CPU) chips, which powered pre-AI personal computing.[94] GPUs, by contrast, power deep learning applications, a core building block of AI.[95]

In addition, Taiwan has a burgeoning startup sector that is gaining investor interest. Taiwanese startup Appier helps increase the effectiveness of digital ad campaigns.[96] To do so, it tracks target buyers' usage behavior across their devices, including the iPhone, iPad, and laptop. Appier then combines that with AI analysis of purchasing behavior for a given product, to serve ads to the target users' suite of devices more efficiently. It has helped a low-cost airline target people who had visited its website, presumably shopping for airline tickets. Appier blended cross-device analysis of those who had visited the site with AI analysis of user-completed bookings (using data like on which day of the week and at what time of day most tickets are purchased, whether the buyer was at work or at home, etc.) to serve ads to the target group, resulting in higher click-through rates, a proxy for effectiveness, at reduced cost.

SOUTH KOREA

South Korea is typically viewed as a "fast follower" in manufacturing, one that can take existing products like semiconductors, cellphones, or televisions and manufacture them more cheaply and with better design and quality. Chaebols like Samsung, Hyundai, and LG, which dominate Korea's manufacturing base, remain key drivers of Korea's private R&D technology spending, including in fast-growing areas such as AI.[97] Samsung Electronics alone invested 14 trillion won (or around US$12 billion) in R&D in 2016, much of it for AI and IoT and autonomous driving.[98] Samsung has plans to incorporate AI into the wide range of products it manufactures. In 2016 it acquired Viv, a company founded by the inventor

of Apple's digital assistant Siri, and has rolled out Bixby, its own voice-activated digital assistant on its Galaxy S8 smartphones.[99]

Hyundai Card uses AI to provide personalized customer service to its credit card customers. The company has been hiring world-class data scientists and engineers to develop distributed machine learning algorithms and to build new opportunities for the brand. For example, it has built algorithms that can infer what types of promotions would be most pleasing to customers. "If you know which movies and music a person likes, you can predict what type of fashion the person likes," CEO Ted Chung said in an interview with the *Seattle Times*.[100] AI also plays a key role in both underwriting and fraud detection. Hyundai Card Artificial Intelligence is fueled by analyzing large quantities of data on customer behavior and characteristics from financial transactions, geo-location, and mobile activity data generated by its user base.[101]

Hyundai Motors in 2016 spent 2.4 trillion won on R&D. Aside from ongoing R&D for conventional vehicles, it is exploring multiple dimensions of autonomous driving. Hyundai and partner firms like Cisco are collaborating on connecting smart cars with people's homes, offices and other urban infrastructure, creating networks of "connected cars." Hyundai Motor opened Project IONIQ Lab, partnering with Seoul National University to prepare Hyundai for the major trends affecting the automobile industry in the future, like safer travel through predictive traffic monitoring, cleaner and more energy-efficient vehicles, and the convergence of "driving and other aspects of everyday life into one seamless reality."[102]

LG Electronics spent 2.2 trillion won on R&D in 2016.[103] Earlier this year, it showcased its SmartThingQtechnology, an IoT for the home, linking devices like stoves, refrigerators and washing machines, robot vacuum cleaners, and others together.[104] LG also showcased a "hub robot" that uses Alexa, Amazon's voice assistant, to coordinate the activities of all the smart appliances in a home. Over time, the appliances and the hub robot "learn" and adapt to the activities and schedules of the home's occupants, performing chores like laundry and vacuuming at the most convenient and energy-efficient times of day. The hub-robot is humanoid in form and can also play music or read children bedtime stories on command.[105]

HONG KONG

Hong Kong punches notably below its weight relative to its Asian Tiger peers on the AI^2 measure of resilience and preparedness, although it is home to a relatively high number of top computer scientists and it ranks just after Singapore in terms of the number of academic papers published. Perhaps that emphasis on academia is the impetus behind one of Hong Kong's notable AI startups, noted by Crunchbase. It is Snapask, a program that allows students to connect with Snapask tutors for help with their homework. From a simple service of ask and answer, Snapask now uses AI cloud-based technology to aid students in need. The website promises tutorial expertise in a broad range of subjects, "HKDSE. PSLE. O levels. N levels. A levels. Even the prestigious International Baccalaureate Diploma Programme. No matter if it is Chinese, English, Maths, Business, Literature or Science, we cover them all."[106]

INDONESIA

Indonesia is still working to fully enter the digital age. The "1,000 Startup Digital National Movement Program," launched in August 2016 to equip Indonesian businesses with digital capabilities, is completing the incubation stage in Jakarta, Surabaya and Yogyakarta, with more cities planned to follow.[107] Indonesia is home to more than 100 million Internet users and 80 million smartphone users, which means a vast amount of potential data for companies that can crack the market for AI-enabled products and services.[108] While Indonesia has not produced its own notable AI startups, a number of Singaporean firms have focused on the Indonesian market. Ematic Solutions is a Singapore-based digital marketing startup that has received funding from Telekom Indonesia's venture capital arm. Ematic uses AI to capture data about visitors to a company's website. It then analyzes the data on customers' interaction with the site to build a database of potential customers and to craft more effective digital ad campaigns.[109]

BLOCK71 Jakarta, a notable private sector initiative announced in late July, between Salim Group and the National University of Singapore's NUS Enterprise, the entrepreneurial arm of the university, will provide an ecosystem for disruptive technology startup companies. According to a press release on the launch, BLOCK71 Jakarta is a 1,500m^2 tech incubation facility located in Kuningan, home to Jakarta's thriving technology community. The new venture "will be a launch pad for Singapore entrepreneurs and innovators to build ties with the Indonesian start-up community, and explore opportunities to work together." BLOCK71 is the third in a growing global network of incubation hubs managed by NUS, which include ventures in Singapore, San Francisco, and plans to expand to Suzhou in China.[110]

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