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AI REVOLUTION IN EMERGING ECONOMIES: ANALYSIS FROM CHINA AND INDIA

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ABSTRACT

The Artificial Intelligence (AI) industry has experienced explosive developments over the last decade. While substantial research has been conducted to discuss the importance of AI for the future of society, the majority of existing literature focuses on a handful of leading AI companies, usually from Western developed economies. Few studies discuss the growth of AI in emerging economies. This gap is notable given that many business analysts and scholars believe that some emerging economies will disrupt Western countries for industry leadership over the next decade. To address the above mentioned research disconnect, we analyze the AI industry of China and India by illustrating their government initiatives, competitive advantages and disadvantages, and major cities for AI development. Recommendations for policy makers and business managers are provided at the end.

I. INTRODUCTION

At a Go tournament on March 19, 2016, Google's artificial intelligence (AI) computer program AlphaGo defeated the world's top human player Lee Se-dol in 4 of 5 games. At first glance, this news seems unimpressive, as Deep Blue beat the world's best chess player Garry Kasparov in 1997. However, Go is exponentially more complex than chess, leading many scientists and business analysts to claim AlphaGo's victory as a pivotal moment in the history of AI. Go originated in China more than two thousand years ago as an abstract simulation of war. Go's rules are simple, but there are a nearly endless number of possible moves. A game of 150 moves (approximately average for a game of Go) may involve 10^{360} possible configurations, which is greater than the number of atoms in the universe (Granter, Beck, & Papke Jr, 2017). With such complexity, Go was labeled the "Holy Grail" of AI (Taal, Sherer, Bent, & Fedeles, 2016). Since this victory, AI programs have overtaken human pros in even more complex games such as StarCraft 2 and poker. Unlike Chess and Go, these games provide players with imperfect information. Winning requires constant iteration of strategies and well-educated guesses about your opponent.

The term artificial intelligence (AI) was coined in 1955 by John McCarthy, an assistant professor at Dartmouth, for the first academic conference on the subject. It refers to machines that are capable of performing tasks that approximate human intelligence through programs and algorithms. Since the early 1990's, the AI industry has grown rapidly through simultaneous advances in computing power and big data. AI technologies, including machine

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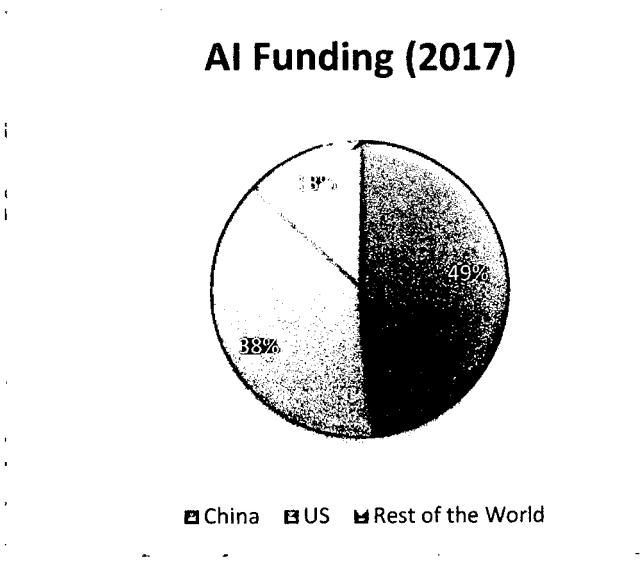
learning, robotic process automation, and language processing have been applied in a variety of areas such as healthcare, manufacturing, business, media and education (Jarrahi, 2018). The apparent return on investment has spurred most industries to transform their core processes and business models to harness new AI technologies. Examples of this trend include content recommendation, fraud identification, and process optimization. Although extensive academic research and business analysis have discussed the AI revolution, most focus has been on achievements of Western developed countries (Brougham & Haar, 2018; Chen, 2016; Dietrich, Bruckner, Zucker, & Palensky, 2010; Martínez-López & Casillas, 2013). In addition, most of these studies concentrate on a few leading Western giants such as Google, Amazon, Microsoft, IBM, and Intel. This has resulted in a dearth of AI literature in emerging economies. With the AI industry booming worldwide, many emerging economies, such as China, India, and Russia have seen their own rapid development. The recent business report highlights seven countries "in a race to rule the world with AI". Three of these seven countries are classified as emerging (Forbes, 2017). Many business organizations predict that some emerging economies, such as China, will outperform the U.S. as industry leader over the next decade. (BCG, 2018). To address the above research gap, we analyze the AI industry in the two largest and most influential emerging economies, China and India, to provide a broad overview of trends. We start with a brief introduction of each country's government initiatives and primary AI hubs. Next, we analyze the respective competitive advantages and disadvantages of both countries for AI development. Last, we present our recommendations to policy makers and business managers.

II. GOVERNMENT INITIATIVES ON AI DEVELEOPMENT

In emerging economies like China and India, government policy plays a critical role in guiding national direction through extensive control over the distribution of scarce resources. Policies regarding land use, taxes, intellectual property laws, and labor market regulations could make or break nascent industries (Yang, Ma, Zhang, & Hong, 2018). Recently, the governments of China and India have realized the economic value of AI and implemented programs to foster its domestic growth.

In 2017, China officially released its roadmap for global AI leadership, the "Next Generation Artificial Intelligence Development Plan", a three step plan. First, China must keep pace with all major AI technologies and their general applications by 2020. Second, China must make major technological breakthroughs of its own by 2025. The third step is to utilize these homegrown innovations to become the world leader in AI by 2030, with a domestic market worth US$150 billion. To facilitate this long-term objective, the Chinese government has made several strategic moves. China's investment in AI is now provided with substantial financial support through direct funding by the country's national bank. This guaranteed governmental endorsement has enabled China to dominate AI funding.



In 2017, 48% of total global equity funding for AI start-ups came from China, compared to 38% from the US, and 13% from the rest of the world (Robles, 2018). In addition, the Chinese government has appointed four major technology companies, Baidu, Alibaba, Tencent, and iFlyTek, as their respective "national champions" to lead development of innovative platforms for self-driving vehicles, intelligent cities, digital vision for medical diagnosis, and voice intelligence. AI's key role in Beijing's 'Made in China 2025' masterplan has stimulated individual Chinese provinces to compete against each other. This internal competition has been buoyed by the central government to create a unified desire to become a technology poster child for China as a whole.

Similarly, the Indian government has begun taking an active role in national AI development. These efforts included the allocation of $480 million in its 2017 budget for investment into emerging technologies such as AI. In June 2018, the National Institution for Transforming India (NITI) published a discussion study outlining India's national AI strategy. The NITI emphasized five major sectors of AI application: healthcare, agriculture, education, smart cities and infrastructure, and smart mobility and transportation. The study identifies three approaches in which AI can meet India's needs. First, AI will contribute to India's economic growth by overcoming the physical limitations of capital and labor to open up new sources of value. Second, AI applications in the social sector will improve the lives of ordinary citizens. Third, India could serve as a tinkering lab to develop new AI technologies for other emerging economies (Aayog, 2018).

III. AI HUBS IN CHINA AND INDIA

Although AI companies that have blossomed across China and India to compete in the global marketplace, there are a few major cities in each country that receive the lion's share of attention.

A. Beijing, China

The largest AI hub in China is the capital, Beijing, which hosts around 1000 AI companies of all sizes. As China's political center, Beijing has many unique advantages. Unsurprisingly, companies based here find it easier to weave political ties with central government officials. In emerging economies like China, political ties are critical for the survival and success of a firm. As the central government takes an active role guiding economic activity through industry development plans and regulatory policies, political ties can provide firms with crucial access to policy and aggregate industrial information (Sheng, Zhou, & Li, 2011). In addition, a firm's relationship with government officials can open access to the central government's extensive control over resources such as land, bank loans, and tax breaks (Peng, Tan, & Tong, 2004). Beijing is home to China's top universities and research institutions. Universities are essential for innovation, especially in high-tech industries such as AI. In order to further position itself as China's number one AI hub, Beijing has recently unveiled a macro-plan with support from the central government and top research institutions. The central government is preparing to build a technology park in Beijing dedicated to AI research. This "national AI research center" is expected to generate $7.7 billion per year by housing 400 enterprises (Galeon, 2018).

B. Shanghai, China

Shanghai has become a leading AI hub in China and harbors more than 200 AI startups. Shanghai plans to expand the AI industry to more than $15 trillion by 2020 according to its new municipal plan. Like Beijing, Shanghai enjoys many unique competitive advantages compared to other major Chinese cities. As the wealthiest city in China, Shanghai has the most advanced internet infrastructure and fastest broadband internet speeds. Shanghai's position as the commercial and financial center of eastern China attracts top talents from nearby provinces including Jiangsu and Zhejiang, which are considered to be China's most dynamic and educated regions. The city's deep historical experience with foreign companies, coupled with favorable governmental policies has attracted branches, regional centers, or even the headquarters of most Fortune 500 companies. This gives domestic companies the opportunity to learn advanced technological and managerial skills from international industry leaders. An example of this potential is the recent announcements by two international AI giants, Microsoft and Amazon, regarding the creation of AI-related innovation centers and research institutes in Shanghai (Xinhua, 2018). As one local government official mentioned: "Shanghai's rich big data resources, wide application of smart technologies and sufficient industries, as well as it's affluent research talents, have laid a solid foundation for the development of the AI industry." (Roy, 2018).

C. Shenzhen, China

Shenzhen was the first place for China to test its modern economic reforms. After 30 years of development, the city has grown from farming villages and rice paddies to become one of the largest metropolitan areas in China. Its population of over 12 million and extensive industrialization make it rival to its well-established neighbor Hong Kong in almost every way. With tens of thousands of factories, Shenzhen is widely considered as a one-stop-shop for small

electronics (Forbes, 2016). Shenzhen is also known as the birthplace of some of China's leading high-tech companies such as Tencent and Huawei. Many of these companies have already established their own AI labs and made AI a top priority. There are over 100 AI startups in Shenzhen. Shenzhen is home to 20% of the country's Ph.D. holders, and has the highest rate of Chinese business owners. The city and has produced more billionaires than anywhere else in China.

D. Bangalore, India

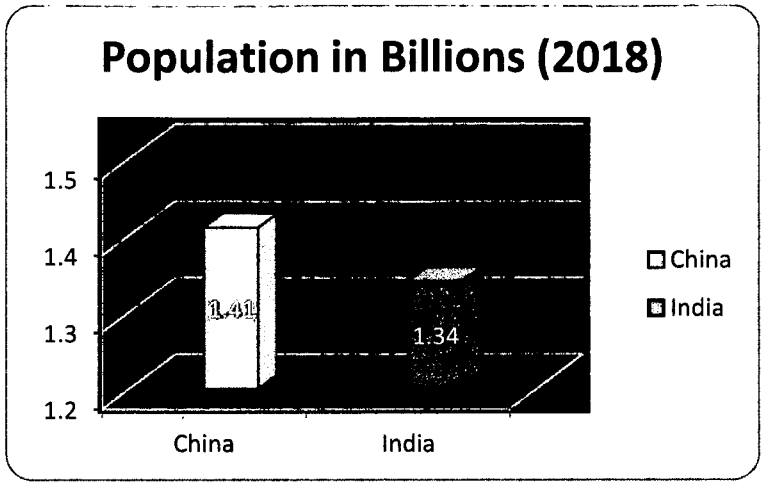
Bangalore is the capital city of the state of Karnataka and has won the "Silicon Valley of India" moniker due to a large concentration of engineering and information technology firms. Bangalore is considered to be a major hub of global innovation (Krishnaswamy, Subrahmanya, & Mathirajan, 2015) (Rogers, Takegami, & Yin, 2001). The city's AI talent pool is enhanced by internationally renowned research institutions and R&D centers. These facilities continue to produce young qualified graduates for AI companies to recruit. The mix of talent and positive entrepreneurial environment have encouraged many companies to establish their offices in Bangalore. Some of the top AI firms in Bangalore are: AIndra Systems, Artivatic Data Labs, Formcept, and Locus.sh. To further assist AI startups throughout their development, local authorities have established several supporting institutions, including the Karnataka Council for Technology Up-gradation (KCTU), Central Manufacturing Technology Institute (CMTI) and a regional branch of the National Research Development Corporation (NRDC).

IV. MAJOR COMPETITIVE ADVANTAGES

Previous research suggests that an industry's overall performance is largely determined by the conditions and environments of its home country (Griffiths & Zammuto, 2005; Porter, 1990). Due to unique demographic and economic factors, China and India share four major competitive advantages for the AI industry: huge market size, urgent demand, burgeoning talent, and data.

A. Huge Market Size

Both countries have substantial market potential for the development of AI industry.



Statistics show China and India as the world's most populous nations with around 1.41 and 1.34 billion citizens respectively (World Bank, 2018). Large populations traditionally mean large potential markets. This is particularly noticeable in China and India given each have rapidly rising middle classes seeking to embrace sophisticated technologies to improve their quality of life. Many of these technologies either use AI directly or are in the early stages of their adoption. For example, in 2017, over 40 percent of global e-commerce transactions took place in China. This was more than France, Germany, Japan, Britain, and the US combined. All major online retailers, such as Jingdong, Suning, and Alibaba have embraced AI technology for tasks like product recommendations based on users' online history and behavior. In 2017, Alibaba's record haul of $25.3 billion during Singles' Day was largely credited to AI, machine learning, and cloud computing.

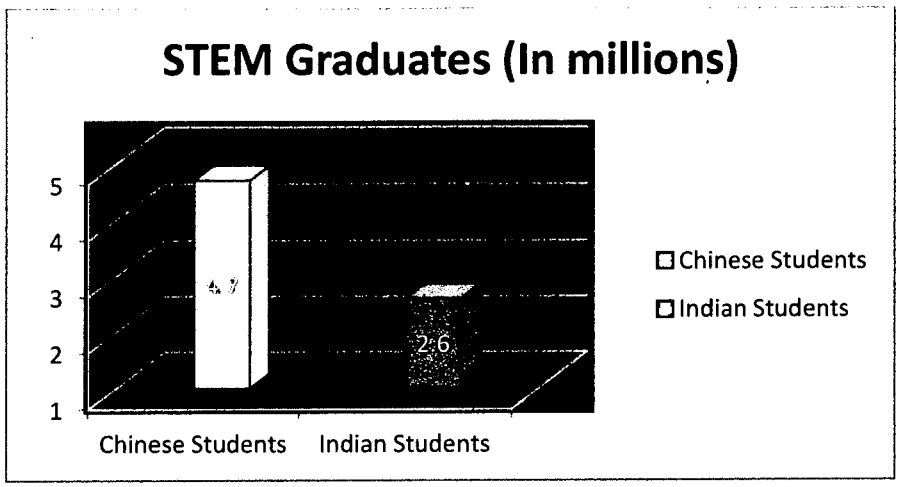
B. Urgent Demand

Over the last few decades, market demand in China has benefited greatly from a "demographic dividend," as its skilled and low-cost labor workforce has fueled economic growth. However, China has been losing this "golden period" as its population ages gradually (Chatterjee, Nankervis, & Connell, 2014). This demographic trend portents that China will fall well short of the workforce needed to sustain economic growth at current productivity levels. AI could partially close this gap. AI systems can improve productivity by completing existing job activities more efficiently, either by assisting or replacing humans. A recent business report estimates that China's AI industry will grow by over 50% over the next decade (ChinaDaily, 2018).

India faces similar pressures to develop its AI industry. India is a vast country with significant areas still lacking modern infrastructure or access to primary healthcare facilities. These issues, together with a chronic shortage of doctors make it challenging for the government to provide quality healthcare for its citizens. AI is expected to partially ameliorate this situation. With the effective use of data and algorithms, AI has been used to analyze and review X-rays, EEG machines, and other images. In addition, AI can help detect fatal diseases such as cancer to ensure lower cost preventive treatment instead of reactive care.

C. Sufficient Talent and Data

The number of STEM (science, technology, engineering and mathematics) graduates is widely considered a vital indicator of a nation's AI talent pool. Youth in China and India have long preferred majors in computer science and engineering.



Given their large populations, this social cachet has translated into a reported 4.7 million Chinese and 2.6 million Indian STEM graduates in 2016. These numbers are shocking compared to the U.S. total of slightly more than 0.5 million (McCarthy, 2017).

Besides talent, big data is often considered equally critical to AI development. As one of Google's top managers put it, "A good AI engineer with a lot of data will beat a great AI engineer with an average amount of data." (Kulp, 2018). Two features place China and India in a strong position to generate and exploit big data – the sheer size of population, and rapid internet adoption. In 2017, there were over 731 million Chinese, and 460 million Indian internet users. Their user bases are the two largest worldwide, and each greater than the overall population of the U.S. (ICAEW, 2017). Similarly, China and India hold the world's largest number of mobile device subscriptions, and their users quickly adopt new digital capabilities. Over the last decade, the value of China's e-commerce has jumped from 1% of global transactions to over more than 40%. The value of individual consumption through mobile devices in China was over US$ 700 billion in 2016, around 11 times that of the U.S. (McKinsey_Global_Institute, 2017). By implementing advanced learning algorithms, the sheer volume of internet users and big data can provide significant advantages. More data can power more accurate predictive models, richer analysis of correlations and patterns, and fast scaling of new data-centric business models. It also supports more advanced machine learning and deep learning techniques. While big data isn't everything, it positions China and India at the forefront of AI opportunities.

V. MAJOR COMPETITIVE DISADVANTAGES

Despite the advantages that China and India have over other economies, they face potentially debilitating competitive disadvantages. The most important deficiencies are substandard administration, inferior infrastructure, and weak protection for intellectual property.

A. Administrative Challenges

Emerging economies like China and India are characterized by industries in transition, inefficient markets, and active government involvement (Xu & Meyer, 2013). In order to improve the development of the AI industry, both countries must overcome three main administrative hurdles. First, regional disparities in economic and institutional reforms run counter to the central government's goal of facilitating AI growth through efficient administration. (Sheng et al., 2011). For example, while some provinces in China are consistently improving their administrative environment to lure foreign AI companies, others have become less business friendly (Banalieva, Eddleston, & Zellweger, 2015). As such, foreign AI companies can experience dramatically different levels of administrative support across different Chinese regions. Second, the uneven governmental policies of both countries is exacerbated by endemic corruption and bureaucracy. This can cost AI companies substantial time and resources to invest in R&D. Simply maintaining a good relationship (guanxi) with the end user is not enough for firms to sell high-tech products such as AI equipment to China's government or state enterprises. The purchase decision making process usually involves multiple government agencies at various levels. These agencies may be primarily designated as regulatory, economic, etc., but frequently squabble to expand their influence. This complex and time-consuming hierarchical approval procedure means that contact points should be developed throughout the chain, from central ministries in Beijing, to provincial and local government bodies, and finally the end user (Tsang, 1998). India has similar issues and has one of the most stiffing bureaucratic systems in the world. Starting a business in India is incredibly difficult, and fully enforcing contracts can be nigh on impossible. The third hurdle for domestic AI development in emerging economies is to attract investment and support from foreign industry leaders. Efforts to attract this capital has been stymied by clear favoritism of Chinese and Indian governments for domestic over foreign-owned companies. Foreign high-tech firms believe that domestic competitors are gaining quicker product approvals and licenses, and preferential treatment acquiring government contracts. Surmounting these administrative challenges will be critical for both countries to further develop their AI industries.

B. Inferior Internet Infrastructure

Secure, reliable internet infrastructure is required for many core AI functions including machine learning, cloud computing, and data mining. These requirements are a problem for China and India's woefully inadequate internet infrastructure, which lags far behind developed economies. In a 2016 test of 200 countries, China ranked 141st, with an average broadband speed of just 2.4Mbps. With limited access to high quality internet, most users are unable to utilize a full range of internet services. This limited bandwidth means fewer services to improve productivity through mobile devices. As such, studies show that mobile

devices in the Asia-Pacific region are primarily used for entertainment (GSMA, 2015). This has a direct impact on the development of AI in China. Companies that set up data centers in well-connected major cities have found China's limited peering points, fragmented network topology, and poor connectivity frustrate content delivery across the entire region. India's internet infrastructure is even worse. In 2015, only 22% of Indian adults had access to the internet. India lacks the routers, fiber optic links and servers needed to expand this access. Few public Wi-Fi spots exist, and broadband connections with faster speeds require infrastructure rarely found in urban low-income areas, much less rural ones. With more than half of India's population earning less than $80 a month, the basic costs of internet-connected devices can be prohibitively expensive. To get around this barrier, Indians frequently buy their smartphones used. However even less expensive devices with limited memory and modern functionality are difficult for many people to afford (Wu, 2016).

If the speed, reliability, and comparative cost of the upcoming 5G technology are anything near industry predictions, China and India could quickly remedy their network disadvantages. 5G promises broadband class speeds to end users without expensive improvements such as laying fiber-optic cable. However, 5G remains largely unproven in large scale use cases. Among other questions are serious concerns about its true performance in densely populated urban areas. These concerns have failed to dampen a frenzy of investment from industry leaders and national governments who consider 5G the foundation of a new communication revolution. This focus makes the field a useful pawn in political disputes involving communications technology that flared out of the U.S surveillance capabilities leaked by Edward Snowden in 2013. Governments now recognize internet infrastructure as fully entwined with national security and economic prosperity. The ongoing trade war between China and U.S. has seriously undermined China's plan to position domestic powerhouse Huawei at the forefront of 5G innovation and development. Many Western countries are following the U.S.'s lead by either limiting or outright banning Huawei (and other Chinese firms) access to their 5G markets and technologies. Despite this, the Chinese government has earmarked billions for Huawei to expand 5G in China.

C. Weak Protection of Intellectual Property Rights (IPR)

Previous literature has shown that strong protection of intellectual property rights (IPR) could promote companies' innovation initiatives by preventing expropriation and infringement. These protections increase motivation of companies to invest in R&D and innovate new products (Autio & Acs, 2010; K. G.-L. Huang, Geng, & Wang, 2017). Compared to developed countries with established IPR laws, emerging economies such as China and India are struggling to effectively protect IPR due to immature regulation, weak enforcement, and non-transparent decision making processes (Lin, Lin, & Song, 2010; Peng, Ahlstrom, Carraher, & Shi, 2017). Although "modern" IPR law has been established in China since 1985 and undergone multiple reforms, it still requires significant improvements to be consistent with long-established IPR systems in the developed world (K. G. Huang, 2010). Many leading AI companies hesitate to enter the Chinese market due to valid concerns about loss of intellectual property. This apprehension is even greater when it comes to conducting R&D and joint projects with domestic Chinese partners. This issue was highlighted by a recent study, which showed that foreign companies are reluctant to form technology-sharing partnerships with Chinese companies for fear local counterparts will renege on agreements after receiving the technology (Deloitte, 2018). The Chinese government has repeatedly failed to protect

intellectual property to the standards of most developed countries, and IP rules often go unenforced. Local governments in many provinces still lack understanding of the importance of protecting trade secrets. The promise and perils of the Chinese market are exemplified by Microsoft. After years of fruitless official complaints about rampant software piracy, Microsoft attempted to force Chinese users to purchase licensed copies. In an allegedly unrelated move, the Chinese government, whose own offices would need to upgrade legacy Microsoft products, has raided regional Microsoft branches and threatened crippling anti-trust violations. Microsoft quickly reversed course and partnered with the government to develop a special version of Windows 10 for the Chinese market. The company censored its search website Bing to Chinese standards and invested heavily in local R&D. While these efforts have resulted in record growth, they increased exposure to government meddling.

The Indian government has similar problems protecting IPR. Despite increased legal protection, copyright infringements are still rampant due to lax administration and enforcement practices. Governmental policies often fail to protect innovations in life sciences, including valuable biotechnology and pharmaceutical discoveries. Without reliable and transparent administrative support, AI companies are less motivated to invest in Indian R&D projects that require substantial financial and human resources. As such, poor protection for IPR will further hamper the development of AI industry in both countries.

VI. RECOMMENDATIONS FOR POLICY MAKERS AND BUSINESS MANAGERS

Based on the above discussion, the undeniable rapid growth of AI industry in both countries shows that their competitive disadvantages can be overcome. We make the following recommendations for policy makers in emerging economies and to top managers of Western AI firms to further this development.

We have four recommendations for policy makers in China and India. The first is to provide consistent administrative support. Reliable administrative support and favorable government policies are particularly important for AI firms, as their R&D investments usually require substantial financial resources and long-term commitment. This rule is especially evident for Western AI firms competing in emerging economies like China and India. During the transition process, policymakers in emerging economies have been constrained by relatively weak institutional frameworks with opaque decision-making processes (L. Wang, Sheng, Wu, & Zhou, 2017). Maintaining the status quo will continue turbulent government policies which pose severe difficulties for AI firms (Yang, Ma, Zhao, Cater, & Arnold, 2018).

Second, the protection of intellectual property rights. Technology infringement is considered the fastest way to lose competitive edge. This is of primary concern to AI firms, whose intellectual property is a core competitive advantage and most valuable asset. Intellectual property may also be essential to obtaining venture capital. In order to further develop AI industry, local authorities must make a concentrated effort to help AI companies defend their intellectual property. These initiatives could include establishment of special government agencies, amending existing regulations, and effectively enforcing IPR law.

Third, encourage fair competition. Fair competition refers to a free market in which all competitors compete on the basis of price, quality and customer service. While no market is truly free, emerging economies tend to excessively hamper competition through non-market factors such as exclusive governmental subsidies, internal transactions, and discriminative pricing. In China, many private companies feel that they are unfairly treated in licensing and regulatory enforcement when competing with state-owned enterprises. In addition, certain

foreign companies must overcome challenges such as "local protectionism" or "consumer animosity" (Fong, Lee, & Du, 2013; Y. Wang, 2016). These unfair treatments will ultimately discourage the entrepreneurial initiatives of private or foreign businesses.

Fourth, attract better AI talent. Developing AI industry requires highly skilled and trained technology professionals. Although China and India educate the most STEM graduates in the world, brain drain has sapped many of the best and brightest. Over the last three decades, hundreds of thousands of Chinese and Indian professionals have migrated to more developed countries in pursuit of lucrative careers and elite education (Chatterjee et al., 2014). This was primarily because neither country could provide comparable financial prospectives and quality of life. This problem is more serious in India. For example, between 2003-2013, the number of Indian-origin scientists and engineers living in the U.S. grew by over 80% (Nagrale, 2017). To better attract AI talent, local authorities should help tech professionals translate their skills into gainful employment or starting their own business. Favorable financial and regulatory support is also important to lure expatriate technicians back home.

We offer two recommendations for managers of Western AI firms. First, observe emerging markets closely. The AI industry has grown explosively in China and India. With the support of favorable governmental policy, lavish R&D funding, improved internet infrastructure, and hard-working engineers, both countries are catching up, or even surpassing many developed countries in certain areas. Western AI firms should take this change seriously as a challenge and opportunity.

Second, Western AI firms should be willing to cooperate and learn from their competitors in emerging economies. Even current industry leaders can gain valuable insights by working with emerging market rivals. Huge market potential makes emerging markets a great opportunity to maintain sustainable growth. Thus, global expansion should be part of the long-term strategy of Western firms. Developing partnerships with domestic AI firms is especially helpful during the initial penetration of an emerging market. These firms normally have better knowledge regarding local consumer needs, and are experienced navigating often confusing industry and government policies.

VII. CONCLUSION

Over the last two decades, the AI industry has grown dramatically with advances in computational power and big data. Although substantial research discusses the importance of this trend, the vast majority of these studies are based on Western experience. Few studies have covered the evolution of AI in emerging economies. With the AI industry quickly becoming a global market, it is important to remedy this knowledge gap. This study provides a big picture analysis of AI industry in the two largest emerging economies, China and India. AI has already changed, and will continue to change our daily lives. Western AI firms and firms from emerging economies should think beyond traditionally zero-sum competitive frameworks, strengthen their own advantages, cooperate with each other, and ultimately provide the world a better future.

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