CONVENED BY GEORGE P. SHULTZ

# GOVERNANCE IN AN EMERGING NEW WORLD

## CHINA IN AN EMERGING WORLD

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# A Letter from the Conveners

Sharp changes are afoot throughout the globe. Demographics are shifting, technology is advancing at unprecedented rates, and these changes are being felt everywhere.

How should we develop strategies to deal with this emerging new world? We can begin by understanding it.

First, there is the changing composition of the world population, which will have a profound impact on societies. Developed countries are experiencing falling fertility and increasing life expectancy. As working-age populations shrink and pensions and care costs for the elderly rise, it becomes harder for governments to afford other productive investments.

At the same time, high fertility rates in Africa and South Asia are causing both working-age and total populations to grow, but that growth outpaces economic performance. And alongside a changing climate, these parts of the world already face growing impacts from natural disasters, human and agricultural diseases, and other resource constraints.

Taken together, we are seeing a global movement of peoples, matching the transformative movement of goods and of capital in recent decades—and encouraging a populist turn in world politics.

Second is automation and artificial intelligence. In the last century, machines performed as instructed, and that "third industrial revolution" completely changed patterns of work, notably in manufacturing. But machines can now be designed to learn from experience, by trial and error. Technology will improve productivity, but workplace disruption will accelerate—felt not only by call center responders and truck drivers but also by accountants, by radiologists and lawyers, even by computer programmers.

All history displays this process of change. What is different today is the speed. In the early 20th century, American farm workers fell from half the population to less than five percent alongside the mechanization of agriculture. Our K-12 education systems helped to navigate this disruption by making sure the next generation could grow up capable of leaving the farm and becoming productive urban workers. With the speed of artificial intelligence, it's not just the children of displaced workers but the workers themselves who will need a fresh start.

Underlying the urgency of this task is the reality that there are now 7.6 million "unfilled jobs" in America. Filling them and transitioning workers displaced by advancing technology to new jobs will test both education (particularly K-12, where the United States continues to fall behind) and flexibility of workers to pursue new occupations. Clearly, community colleges and similarly nimble institutions can help.

The third trend is fundamental change in the technological means of production, which allows goods to be produced near where they will be used and may unsettle the international order. More sophisticated use of robotics alongside human colleagues, plus additive manufacturing and unexpected changes in the distribution of energy supplies, have implications for our security and our economy as well as those of many other trade-oriented nations who may face a new and unexpected form of deglobalization.

This ability to produce customized goods in smaller quantities cheaply may, for example, lead to a gradual loss of cost-of-labor advantages. Today, 68 percent of Bangladeshi women work in sewing, and 4.5 million Vietnamese work in clothing production. Localized advanced manufacturing could block this traditional route to industrialization and economic development. Robots have been around for years, but robotics on a grand scale is just getting started: China today is the world's biggest buyer of robots but has only 68 per 10,000 workers; South Korea has 631.

These advances also diffuse military power. Ubiquitous sensors, inexpensive and autonomous drones, nanoexplosives, and cheaper access to space through microsatellites all empower smaller states and even individuals, closing the gap between incumbent powers like the United States and prospective challengers. The proliferation of low-cost, high-performance weaponry enabled by advances in navigation and manufacturing diminishes the once-paramount powers of conventional military assets like aircraft carriers and fighter jets. This is a new global challenge, and it threatens to undermine U.S. global military dominance, unless we can harness the new technologies to serve our own purposes. As we conduct ourselves throughout the world, we need to be cognizant that our words and deeds are not revealed to be backed by empty threats. At the same time, we face the challenge of proliferation of nuclear weapons.

Finally, the information and communications revolution is making governance everywhere more difficult. An analogue is the introduction of the printing press: as the price of that technology declined by 99 percent, the volume grew exponentially. But that process took ten times longer in the 15th, 16th, and 17th centuries than we see today. Information is everywhere—some accurate, some inaccurate, such that entire categories of news or intelligence appear less trustworthy. The "population" of Facebook now exceeds the population of the largest nation state. We have ceaseless and instantaneous communication to everybody, anybody, at any time. These tools can be used to enlighten, and they can also be used to distort, intimidate, divide, and oppress.

On the one hand, autocrats increasingly are empowered by this electronic revolution, enabled to manipulate technologies to solidify their rule in ways far beyond their fondest dreams in times past. Yet individuals can now reach others with similar concerns around the earth. People can easily discover what is going on, organize around it, and take collective action.

At present, many countries seek to govern over diversity by attempting to suppress it, which exacerbates the problem by reducing trust in institutions. Elsewhere we see governments unable to lead, trapped in short-term reactions to the vocal interests that most effectively capture democratic infrastructures. Both approaches are untenable. The problem of governing over diversity has taken on new dimensions.

The good news is that the United States is remarkably well-positioned to ride this wave of change if we are careful and deliberate about it. Meanwhile, other countries will face these common challenges in their own way, shaped by their own capabilities and vulnerabilities. Many of the world's strongest nations today—our allies and otherwise—will struggle more than we will. The more we can understand other countries' situations, the stronger our foundation for constructive international engagement.

This is why we have set off on this new project on Governance in an Emerging New World. Our friend Senator Sam Nunn has said that we've got to have a balance between optimism about what we can do with technology and realism about the dark side. So we aim to understand these changes and inform strategies that both address the challenges and take advantage of the opportunities afforded by these transformations.

To do so, we are convening a series of papers and meetings examining how these technological, demographic, and societal changes are affecting the United States (our democracy, our economy, and our national security) and countries and regions around the world, including Russia, China, Latin America, Africa, and Europe.

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The papers included herein explore China's demographic outlook, the use of social media and communications technology by its people and government, and its development of advanced technologies for both economic and military gain. China has enjoyed a period of extraordinary growth and is becoming a world leader in technology, but it must now contend with an aging society and shrinking workforce. Moreover, China's authoritarian leadership wrestles with the governance choices posed by new means of communication. Will China's pursuit of next-generation technologies mediate its government's goals of continued domestic development and increased global influence? An assessment of China's strengths and weaknesses as it addresses the coming demographic challenges and works towards its technological goals can be a first step toward the development of a strategy to deal with China in the emerging new world. To begin that conversation, we have asked scholars from the United States and abroad to contribute their thoughts on these issues:

Nicholas Eberstadt, the Henry Wendt chair in political economy at the American Enterprise Institute, examines China's demographic outlook, identifying not only a coming labor force contraction and an aging society but also long-term problems arising from urbanization and internal migration and shifting family structures. Demographic constraints appear poised to hinder both economic growth and China's geopolitical aspirations.

Center for a New American Security fellow Elsa Kania considers whether there is an "AI arms race" between China and the United States. As both countries develop military applications of AI and other new technologies, such as additive manufacturing, we may see over time a growing military challenge; in the near term, the uncertainty and limitations of AI likely pose a risk.

Looking to the civilian side of technological development, Sinovation Venture's Kai-Fu Lee and Paulson Institute fellow

Matt Sheehan see artificial intelligence transitioning from an "age of discovery" to an "age of implementation." In this next phase of development, companies will apply AI to an expanding set of tasks, but its widespread application threatens to exacerbate inequality and favor monopolies.

Maria Repnikova, assistant professor at Georgia State University, reviews how the Chinese and their government have shaped social media use to their purposes. Although the government has employed them to further authoritarian ends, it has also become more responsive to an increasingly connected and active citizenry.

Finally, former U.S. ambassador to China Stapleton Roy details how the Chinese government plans to become a global leader in these emerging technologies and what that might mean for the United States. China faces a number of domestic obstacles, especially its demographic outlook, but may nevertheless still achieve its ambitious goals. And if it were to do so, it could match or even exceed the United States in economic, military, and technological capacity.

Each of the authors came together this fall for a roundtable at the Hoover Institution to discuss their ideas, to challenge each other's perspectives, and to carry that conversation to the broader Stanford University and Silicon Valley community. We conclude this examination of China in an emerging world with summary observations of that discussion, prepared by us and Hoover research analysts David Fedor and James Cunningham. We wish to extend our thanks to our colleagues at the Hoover Institution who have worked to support this project, particularly to Shana Farley and Rachel Moltz for the creation of this booklet.

**George P. Shultz**
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**James Timbie**
Annenberg Distinguished Visiting Fellow

# China's Demographic Prospects to 2040: Opportunities, Constraints, Potential Policy Responses

**By Nicholas Eberstadt,** American Enterprise Institute

For any serious attempt to assess China's future outlook, an examination of the country's population prospects is not only advisable but absolutely indispensable. There are two reasons for this.[1]

First: of all areas of inquiry of interest to us at this gathering about China's future, it is perhaps China's demographic future that is *least* uncertain over the coming generation. The reason, quite simply, is that the overwhelming majority of the people who will be living in China in (say) the year 2040 are already alive, living there today. Population projections are far from error-free, but if we are trying to peer ahead a couple of decades they are most assuredly more reliable and empirically grounded than corresponding projections of economic change, much less political change or technological change.[2]

Second: demographics and demographic change actually matter—to economic performance, social development, and in some measure as well arguably to such things as military potential, political stability, and international security. This is not to invoke the "demography is destiny" claim, often attributed to the 19th Century French polymath Auguste Comte. A less florid, more immediately defensible reformulation of that aphorism would be that "demographics slowly but unforgivingly alters the realm of the possible". In the following pages we will try to show just how the realm of the possible is being reshaped in China by impending demographic changes over the decades immediately ahead.

**China's Current and Future Population: What We Know and How We Know It**

Before presenting the demographic projections underpinning this paper, we are obliged to address two basic questions about China's demographic outlook: what do we know, and how do we know it? Answering these requires us to discuss data limitations today, and the intrinsic limitations of demographic projections for tomorrow.

Consider first the limits of current Chinese population data. Vastly more population information is available for China today than was the case for most of the Maoist era, when a virtual statistical blackout prevailed; China today also has trained and groomed a large cadre of top-rate demographers and population economists who work in the nation's universities, state-sponsored think tanks, and government. On the other hand, China has not yet achieved complete or near-complete vital registration, meaning that analysts must rely mainly on reconstructions of trends from censuses and "mini-censuses"—and these counts are far from error-free.

Many errors in China's population data are essentially politically induced—the data are deformed by mass misreporting due to ordinary people's attempts to avoid the harsh consequences of Beijing's various population control policies (using that term broadly). With regard to Chinese household registration data (which are derived from a separate demographic system run by the Ministry of Public Security), the 2010 Census indicated that at least 13 million Chinese citizens lacked legal identity papers because they were born "out of *hukou*", i.e., outside the locality that the state mandates to be their residence[3] (more on the *hukou* system shortly). But that guesstimate is based on official assumptions about China's true population totals—and China's vital statistics, census returns, and sample population surveys have undercounted the nation's actual numbers for decades due to Beijing's heinous "One Child Policy" and the familial incentives it established for birth concealment. The United Nations Population Division (UNPD) currently suggests that the 2010 China Census estimate missed the mark by about 30 million, even after its own internal undercount adjustments, and that it may have failed to enumerate well over a quarter of all female children under 15 years of age.[4] From the 1982 China census onward, population totals and sex ratios for given birth years from one census to the next have proved unstable for babies, children and youth. These errors due to politicization of demographic rhythms of life may at perhaps now that Beijing appears to be scrapping its anti-natal campaign—but they are embedded in the data we use for projections to 2040.

As for projections themselves—these are no more reliable than the baseline data they use and the assumptions

they input about future trends in fertility, mortality and migration. International migration is negligible for China in relation to its enormous population, and the assumption is this will continue to be true—lucky that, since demographers have no really defensible method for projecting international migration trends into the future. Demographic techniques for projecting survival trends for the currently living are fairly good—thanks to actuarial mathematics, after all, the life insurance industry has not gone out of business—but catastrophes of Biblical proportion do take place from time to time, and Providence has already visited a number of them on post-Liberation China. As a matter of simple population mathematics, however, fertility trends dominate longer-term population projections, and since there is no reliable method for projecting future fertility levels, assumptions are critical. China clearly undercounts births (with a reported total fertility rate of 1.18 births per woman per lifetime) but no one knows exactly by just how much. The consensus, for better or worse, is that the actual rate in recent years has been around 1.6, or about 30 percent below the level required for long term population stability in the absence of in-migration—but consensuses are not always correct.

**China 2040: The Population Projections**

Like sausages and law, the making of demographic projections may not look so pretty when seen up close. Irrespective: the fact of the matter is that population projections for China are likely to be *less* problematic than for many other countries or regions of the world. China is a low-migration, low-mortality, low-fertility society. This means there is, so to speak, relatively little "turnover" in the population from one year to the next. To go by the projections of the UNPD or the U.S. Census Bureau, almost four-fifths of China's projected 2040 population would be 22 or older then—meaning they have already been born at this writing. This brute fact far outweighs many of the smaller uncertainties highlighted above, and in a sense rescues us from them.

Nonetheless we need to know the assumptions built into the China population projections. Consider UNPD's, which we will mainly use in this paper. (The UNPD's assumptions, by the way, are fairly close to those of the U.S. Census Bureau, and for that matter also the China National Bureau of Statistics.) For the 2015-2040 period, the UNPD assumes negligible net-outmigration from China of 0.2% per year—a rounding error, essentially. With respect to mortality, the UNPD estimates overall male plus female life expectancy at birth was a bit over 76 years in 2010/15, and that it would rise to 80 by 2040/45 (with detailed "life tables" offering survival probabilities for males and females of every age over the interim). As for fertility: the UNPD "medium variant" fertility projections envision a gradual rise in China's TFRs from 1.6 to just over 1.7, meaning that childbearing in China would still be almost 20 percent below the level required for long term population stability around 2040. While this assumption about China's fertility trajectory is highly debatable—future fertility trends are always a "known unknown"—the fact of the matter is this assumption has relatively little influence on our overall assessment of the implications of coming demographic trends. These assumptions, for example, would only affect the small share of the 2040 labor force as yet unborn (those then in their late teens or very early 20s)—and even for this cohort the impact of errant assumptions would be marginal.

Perhaps the clearest and simplest way to see what these changes would portend is to superimpose the projected population structure of China 2040 on the estimated population structure of China 2015. [SEE FIGURE 1]

Overall, total numbers in 2015 and 2040 would be quite similar: somewhere around 1.4 billion. But this is only a coincidence. Due to steep and prolonged sub-replacement childbearing (China's net reproduction ratio is widely believed to have dropped below 1.0 in the early 1990s), China's population would be on track to peak in about a decade 9circa 2028 or 2029), and to shrink at an accelerating tempo thereafter: whereas China is thought to be growing by around 5 million a year nowadays, by these projections it would be shrinking by about 4 million a year in 2040. (In these UNPD projections, incidentally, India edges out China as the world's most populous country just before the year 2025.)

Although China's population totals are similar in 2015 and 2040, a fundamental transformation of China's population structure is manifest in Figure 1—a change so dramatic we might even call it a leap into the demographic unknown. To be sure: there are esoterica in this tableau that would naturally catch a demographer's eye—the population bulge for "the class of 1987", for example, which is itself an "echo" of the upsurge in births in the early 1960s after the end of the famine unleashed by Mao's catastrophic "Great Leap Forward". But the main story on display is the extraordinary redistribution of China's population—upward, toward the top of the so called "population pyramid".

Two broad differences between China 2015 and projected China 2040 stand out. First: the overall population under 50 years of age is larger in the China 2015 than in China 2040—and for certain cohorts, such as those in their mid-twenties or early forties, China 2015 is dramatically larger than China 2040. Second: the overall population over 50 years of age is far larger in notional China 2040 than actual China 2015—over half again as large, in fact—and for many age cohorts, including septuagenarians, octogenarians, and nonagenarians, China 2040's population is vastly larger than China 2015's. In fact, the China of 2040 in Figure 1 would contain a quarter billion more people over 50 more than the China of 2015—

while the ranks of those under 50 would be diminished by almost the same amount.

Most people understand intuitively that steep sub-replacement fertility levels eventually lead to depopulation (absent compensatory immigration). Less appreciated but no less avoidable is the relationship between low fertility and population aging: very small families make grey societies. In these projections, two generations of pronounced sub-replacement fertility would bring China to a place where none have gone before (at least so far). By UNPD medium variant projections, median age in China 2040 would be 47 years—higher than the median age for any country or territory on the planet as of 2015, according to UNDP estimates.

There are other aspects of Figure 1 that a discerning observer may notice—among them, the surfeit of males over females for the cohorts born during the decades of One Child Policy population control. And additional, potentially quite significant, population changes are underway that cannot be detected by a simple "national headcount approach". We now examine these various issues.

**Manpower and Labor Availability**

By 2040, in these projections, China would have experienced almost half a century of sub-replacement fertility—and for most of the decades in question the nation's fertility level would have been far below replacement. Thus it should come as no surprise that the working age population is thought to have peaked just before 2015—and from 2015 to 2040 is projected to shrink at ever greater speed.

By ancient convention, demographers talk of the "working age groups" as ages 15 through 64, and we shall do so as well in this paper. We know this formulation is arbitrary and also a bit archaic: nowhere is everyone between 15 and 64 in the workforce; growing numbers of teens and twentysomethings are out of the workforce because they enrolled in the training they need or want in order to join it; and in the real world ever increasing numbers of people 65 and older happen to be earning pay, in China and elsewhere. Yet as a first approximation the 15-64 cohort may not be a bad one for China's working ages—and in any case population decline is in the cards between now and 2040 for most of the subgroups within this broad category too.

China's past trends and future outlook are presented in Figure 2, which details estimated and projected changes in China's "adult" (age 15+) population by broad age groups from 1970 to 2040. [SEE FIGURE 2]

Between the fateful December 1978 Plenum of the 12 CCP Congress (where Deng Xiaoping pointed China on a historic new economic direction) and 2010, China's working age population grew by about 80 percent, swelling roughly from 560 million to one billion. Thus over that period, overall manpower availability rose by an average of 1.8% per annum, and total national work hours may have risen more rapidly as underemployed labor was absorbed in both the cities and the countryside. But between 2010 and 2015, manpower growth was roughly zero—reaching its projected (all time historical?) peak around 2014. Thereafter, China's working age population is projected to commence a long decline—dropping by well over 100 million by 2040, to around 880 million, at which point it would be shrinking at a rate of 1% a year.

In terms of simple economic "growth accounting", increased labor inputs did not account for all of China's spectacular economic growth during the 1978-2010 period, or even for most of it—but it did account for a hardly trivial fraction of that boom.[5] The coming reversal of the delta for manpower change in the years immediately ahead means that, from the standpoint of the very simplest sort of growth accounting, the Chinese economy will be facing increasingly unfavorable headwinds simply due to manpower decline, everything else being equal.

But everything else will not be equal. We already know, for example, that the composition of the working age population is irrevocably set to change, and in ways that would seem inauspicious for economic growth. Over the coming generation, the pool of young manpower is on track to shrink sharply, with only the pool of older manpower expanding. This is not the way economic planners would have designed things. The youth labor group (ages 15-29) in modern societies always has the highest educational attainment, is the most IT and tech savvy, and tends to be the most flexible (all the more so in China since most people in this age group have not yet started to form families). Between 2015 and 2040, the 15-29 group is projected to shrink in size by 75 million, or roughly a quarter, and to shrink as a share of total manpower from a little less than a third to just over a quarter. The 30-49 group, for its part, might be regarded as a part of the life cycle in which entrepreneurship and inventiveness comes to fruition: Benjamin F. Jones' international findings on "the age of great discovery" are particularly intriguing in this regard. [SEE FIGURE 3] Without getting too deterministic about this, we may entertain the conjecture that Thirtysomethings and Forty somethings add a "secret sauce" to the workforce and the economy. Too bad for China's outlook if so: between 2015 and 2040, this group is projected also projected to shrink in size by a quarter, by well over 100 million men and women, and to drop from 43% to 37% of total manpower. It is only the 50-64 cohort that can be expected to grow over the generation ahead: the least educated and healthy contingent in the labor force (although of arguably also the most experienced)—its share jumps from about 25% of total manpower to about 35% over the years under

consideration, but even projected numbers for this group start to fall before 2040.

Beijing's economic policymakers have some options in responding to this unfavorable impending change. Improving education of the workforce is one option—but the 50-64s of 2040 are already out of school, and China's inverted population pyramid makes the task of increasing overall educational attainment through schooling much slower than would be the case for a youthful population. Raising the capital-labor ratio is another theoretical option (this is what Ronald D. Lee and others call "the second demographic dividend"[6]), but China's gross domestic capital formation ratio today is already bizarrely, perhaps unsustainably, high. Some have argued that China can muddle through this problem by raising labor force participation rates for the working age manpower pool.[7] But it is far from obvious this will be feasible. China's everyday labor statistics are notoriously poor. The most reliable numbers available come perhaps from the 2010 census. If we go by those figures, China's working age manpower may not be as ferociously mobilized as say Kim Il Sung's North Korea[8], but its LFPRs for both men and women are comparable to or higher than most OECD countries, and the same is true for work rates (employment to population ratios).[9] Some might hope there would be room for coaxing additional labor out of China's underemployed adults, especially those in the countryside—but Cai Fang, perhaps China's most eminent population economist, has argued that China already reached the Lewis-model "turning point" a decade ago.[10] Some countries and places—Singapore, Gulf states, and even Western Europe among them—have attempted to redress labor shortages through international migration: but as (currently) the world's largest country, China has a scale problem; attracting 100 million plus workers voluntarily and through economic incentives over the coming generation is simply inconceivable in the world as we know it. There is the option, however, of internal migration: of ramping up productivity for the existing, dwindling manpower pool by moving peasants to more remunerative work in the cities. Beijing has seized on this option and is actively promoting it through its ongoing "National New-Type Urbanization Plan", also widely known as the "urbanization drive".[11] There is promise in this strategy—but as we shall see in a moment, it is not exactly an unalloyed cure.

**Population Aging**

Despite the prospect of overall population decline in the era ahead, China will be experiencing a very particular type of population explosion: an explosive increase in its number of senior citizens 65 years of age and older. Between 2015 and 2040, in these UNPD projections, China's 65+ population would jump by almost 150%: from 135 million to almost 340 million. That is a long-term growth rate of 3.7 percent a year: a breathtaking tempo of growth for any major population group for decades on end, and one that perforce should be expected to shape the nation's economic, social, and perhaps even political outlook. By 2040, if things go well, China will be a "super aged society" with 22% of its people 65 or older (21% being the conventional threshold for defining "super aged").[12] (The only scenarios under which China does not become super aged are catastrophic ones.) By the criteria median age and share of population 65+, China would in fact be more aged than the United States—meaning the United States of 2040 (at least, by Census Bureau projections). How China copes with its coming senior tsunami and the attendant impending old age burden is a critical question for China's future.

Over the past generation there has been considerable research on the role of the "demographic dividend" in spurring economic development.[13] This work holds that the fertility transition offers a once in history chance to accelerate development by raising the share of a nation's working age population—not only increasing the availability of laborers more rapidly than total population, but also propitiously influencing savings and investment possibilities through this shift in population structure. Most population economists today attribute some of China's spectacular success over the past four decades to this "demographic dividend".[14]

For better or worse, China's demographic dividend has already been cashed. Between 1978 and 2010, China's 15-64 group shot up from 58% of total population to an amazing 74%. Now it is on its way back down, and by 2040, in our UNPD projections, it will be back to 62%--where it was in 1982—and still heading south. The dependency ratio of 2040 and 1982 may be identical, but their portent is very different, since almost all of the non-working age population then were children and in 2040 the great majority will be elderly adults.

To be fair: in 2040, on current trajectories, the 65+ population in China will be the healthiest and best educated cohort of seniors that have ever inhabited the Chinese mainland. Among other things, this means they may be *less* economically dependent those before them, more capable of making do financially on their own. But that is a relative comparison. China's seniors in 2040 will also be China's least educated adult grouping. By the projections of the Wittgenstein Centre, for example, in 2040 nearly half (46 percent) China's seniors would have a primary school education or less—i.e. 6 years or less, with 5 percent of them having no education at all. (The corresponding share in 2040 for the 20-39 group would be 13 percent.) Over three fourths of China 2040's seniors would have no more than lower secondary education—i.e. 9 years of school or less. [SEE FIGURES 4 AND 5[15]]Thus paradoxically it is the seniors—China's most physically fragile contingent—who would be the group most likely to be obliged to engaged in physical labor if attempting

to support themselves economically. Professor Wang Feng of UC Irvine and Fudan University and colleagues calculated that as of 2010 Chinese seniors earned less than 40 percent of the resources that were sustaining them at age 65; just 20% at age 70; and maybe 10% at age 75.[16]

Recall as well that the very fastest growing contingent of seniors in China as elsewhere are the oldest-old, men and women 80+ years of age. This group is on track almost to triple as a share of China's population, from 1.7% in 2015 to 4.9% in 2040. The risk of dementia and Alzheimer's increases very rapidly after age 80; until and unless humanity finds the silver bullet for this terrible affliction, the burdens implicit in an Alzheimer's explosion also have to be taken into account with China's senior tsunami. In addition, a steadily growing share of China's seniors and oldest old are living by themselves in one-person households (a trend not particular to China, but to the contrary witnessed worldwide). The especially rapid growth of China's live-alone senior population can only make for additional vulnerability and risk on the years ahead.

Note that the greying of China promises to be a highly varied process geographically, with one of the most dramatic cleavages separating urban and rural China. Projections in collaboration with colleagues by Professor Zeng Yi of Peking University and Duke, one of China's foremost demographers, suggest that rural China is already far greyer than urban China thanks to rural-to-urban labor migration—and that the gap is only set to widen in the decades ahead.[17] [SEE FIGURE 6] Zeng et al anticipate a China in 2040 where something like a third of the rural population would be 65 or older—twice the ratio for urban areas. By way of comparison—the very greyest spot on earth today (2015) according to UNPD is Japan, with 26% of the population 65+. As the famous aphorism notes, Japan got rich before it got old; one does not have to be a Sino-pessimist to recognize that rural China is getting ready to do things the other way around. In fact, China's very greyest regions in the future are most likely to be its poorest, least educated, and least healthy as well; they will no doubt benefit from remittances (from migrant working age children living off in urban China), but only to a degree. Even with better education, health, and capital investment in 2040, seniors in China are set to be dependent on support from resources other than their own earned income.

The question inescapably rises: who will provide for China's immense population of future seniors? A first response would be: current government policies will almost certainly *not* do so—or at least will not do so comprehensively and adequately. Beijing has been dithering about nation-wide public pension and old-age health care guarantees for over two decades now, and while a number of important steps have been taken, the situation is what might charitably be called a work in progress. As of 2017, for example, less than 65 percent of China's working age population was covered by any pension schema, and only 35 percent of urban migrants were covered; in rural areas, for their part, the pension schema offered a "basic benefit" of 70 RMB per month for qualifying retirees—just over $10 per month at today's exchange rates.[18] Even so: China's real existing pension and health system is severely underfinanced, due in part to overpromises to special constituencies such as urban residents and state-owned enterprises (SOE) employees; according to IMF calculations, the implicit debt (net present value of unfunded liabilities) in China's current health and pension programs amounts to about 100 percent of the country's GDP.[19] China's pension liabilities can be reduced through practical and feasible reforms—re-examining vested benefits for urban groups and SOEs, and raising retirement ages from the Stalin-normed levels of 60 for men and 55 for women that were set in the early Maoist era—but that still begs the question of coverage and support levels for the grey needy, of whom there will likely be vast numbers. And this budgetary problem stands in addition to China's other notorious looming debt challenges.

If public policy will not fill the gap, what will? Personal savings are one answer—and uncertainty about future government old-age guarantees may help in part to explain China's strikingly high private savings ratio.[20] But generally speaking, savings and need are inversely correlated in China as elsewhere, meaning China's vulnerable aged of tomorrow cannot count on their own savings and assets for old age security.

China's historic mechanism for assuring care and income security for seniors was called the family. In the event, the family mechanism will no doubt be relied upon to provide for frail and failing elders in the coming generation, too. Just how well it will acquit itself in this task is another question. Two generations of sub-replacement fertility will have taken their toll on the family unit in China 2040 (and on the extended family as well, about which more later). The son—or rather, the daughter-in-law to which he is attached—has been the notional caregiver and provider for aging parents under Chinese norms since at least the consolidation of the Chinese empire under the Qin dynasty.

What happens though when there is no living son? We are about to find out, and bigtime: back of the envelope calculations suggest that the proportion of Chinese women 60 years of age with no male child may have risen from 7 percent in the early 1990s to 30 percent or more for post-2025 China. Dutiful daughters may of course step in, but their loyalty attention and resources may be all too frequently divided, inadequately, between two sets of aging parents.

All of this, however, presupposes that two and a half millennia of Confucian values will inform the behavior of adult children toward their elderly parents in the generation to come. That means taking the near-universal continuation of filial piety for granted. Such devotion might have been easier when the elders were scarce and the children were plentiful; tomorrow those tables will be turned. Beijing has already begun to lay down markers here, criminalizing non-support of parents and even non-visiting in 2013.[21] Why, we may wonder, do authorities feel such laws to be necessary?

We can assume China will be considerably richer in 2040 than today—*ceteris paribus* that would mean more resources for elderly support. Human beings tend to cope—work from Ronald D. Lee's National Transfer Account project has suggested, intergenerational household resource transfers may be quite effective in dealing with population aging in much of East Asia, including perhaps China. Some Pollyannas have even suggested that the sheer scale of need for China's rising cohort of seniors will help the nation undertake much needed reforms, such as a shift to consumption-oriented growth. Suffice it to observe that darker scenarios are also possible—including the prospect in rural areas of something like a pervasive, slow motion humanitarian tragedy, met with Darwinian solutions. It is also not impossible that these "optimistic" and "pessimistic" scenarios could unfold at the same time within the same country.

**Gender Imbalance and "Marriage Squeeze"**

China's eerie and biologically unnatural One Child Policy era upsurge in sex ratios at birth raises another demographic dilemma for China, this one seemingly out of a science fiction novel: the prospect of a Chinese future with a major and persistent shortage of brides.

In normal human societies of any size, there is an abiding regularity to the sex ratio at birth (SRB) across history, countries, and ethnicities: typically running in the range of 103-105 baby boys per 100 baby girls. From the 1982 China population census to this writing, however, weirdly high SRBs have been reported in official Chinese population data. By the 2010 Census, the reported SRB was about 120. In certain provinces, the SRB has reportedly exceeded 130—and in not a few localities, it has exceeded 150. These numbers point to mass female feticide in the context of reliable prenatal gender determination technology and unconditional abortion. China is by no means the only spot on the planet where this is taking place (elsewhere I have written about "the global war against baby girls"[22]), but it is arguably the largest and most brutal battlefront in that campaign.

Given the persistent undercounting of China's babies in the One Child Policy era, we cannot tell directly from official data just how severe China's true SRB distortion has been. It is left to demographers to reconstruct actual trends—and their assumptions about the degree of undercounting can differ; likewise in projections about the future. UNPD today estimates that China's SRB peaked in the 2000s at 117, is currently around 115, and will be 111 around 2040; the Census Bureau says SRB peaked at 118 in 2005, is 113 in 2018, and will be 107 in 2040. (Such differences of course have a multiplier effect on the dimensions of the "marriage squeeze" one envisions for the brides- and grooms-to-be several generations hence, but do not much affect estimates for the dimensions of the "marriage squeeze" facing China in 2040.)

Up to now, family formation in China has been influenced by what we might call a "universal marriage norm," an ethos strongly informed by the Confucian metaphysical imperative of continuing the family lineage through the male issue. Towards the end of the 20th century, that norm was translated into reality: in those years, all but 4 or 5 percent of men and an even smaller fraction of women in their late 40s had been married. Now the arithmetic of gender imbalance means all this must change. It will change even faster, and more acutely, if the universal marriage norm erodes. In almost all the rest of East Asia, that norm has already fallen into considerable disrepair; demographer Gavin Jones in fact talks of a "flight from marriage" in the region,[23] with ever greater proportions of young men and women postponing marriage or forgoing it altogether. If young women in China follow the example of their peers in Japan, Taiwan, Hong Kong, and elsewhere, the prospects for the marriageability of China's prospective future bridegrooms will dim all the more.

In this paper I project one outlook for China's coming "marriage squeeze," utilizing Prof. Zeng Yi's invaluable PROFAMY software for this task.[24] [SEE FIGURE 7] (I regard this as a "middle" variant set of assumptions about fertility, SRBs, "flight from marriage," and the rest: more dramatic scenarios could be imagined.) In this scenario, 20% of Chinese men in their early 40s are never-married by 2030—up from just 4% in 2000. This would be a nationwide average, though: needless to say, the odds of being unable to marry would be higher for men who were rural, poor, and/or poorly educated. Such projections suggest a China 2040 with tens of millions of essentially unmarriageable men (although my method also includes some men who would be voluntarily never-married).

A reality check on my projections comes from UNPD and U.S. Census Bureau projections for China 2040. In UNPD medium variant, there would be 23 million more men than women in the 25-44 cohort, and 29 million more men than women if the more appropriate comparison is men 30-49 for women 25-44. In the Census projections, the corresponding surfeit of marriage-age males would be 22 million and 30 million, respectively, or 13%-17% of the total male reference population. Since we are dealing with

stocks and flows in calculating the prospective marriage squeeze, these figures are not so inconsistent with my own projections.

What will it mean for China to have a growing internal army of unmarriageable young men—a contingent predominantly poor and poorly skilled? Counterintuitively, there may be some positive economic spillovers: some research suggests male competition for brides has already promoted something like a savings race. [25] Economists and public intellectuals like Gary Becker and Judge Richard Posner, further, have mused that the scarcity of females in China would eventually have the beneficial effect of increasing their "value."[26] To date, alas, "rising value of women with Chinese characteristics" has meant kidnapping, sex trafficking and other violations of human rights.

Moreover, there is no obvious policy solution in sight for the coming marriage squeeze. Places like Hong Kong and Taiwan have dealt with their own bride shortages by "importing from abroad"—but China has a scale problem. It also would be in a different segment of the marriage market, requiring (huge numbers of) willing brides for its relatively impoverished hinterlands. Zeng Yi and others have suggested that establishment of solid national pension and health care guarantees would reduce "son hunger" in China, especially in the countryside—but as already mentioned, nothing like this is yet in place in rural areas, and it would take another generation for such policies to affect the marriage squeeze once implemented.

Does China's coming "bare branches" problem portend social or political instability? The question occasions continuing, sometimes heated, debate. Professor Valerie Hudson, author of the "bare branches" thesis,[27] famously argues that a surplus of men tends to make for domestic and international tensions.[28] On the other side, Professor Wang Feng and others have pointed out that a serious surplus of marriage-age men has been the norm rather than the exception throughout Chinese history due to the abhorrent but time-honored practice of mass female infanticide and killing of girls,[29] suggesting that Chinese customs and institutions had long adapted to this demographic anomaly.

Wang Feng et al. have gotten those historical particulars right—what those mean for the future, however, is another question. In the generation ahead, China may well be on the rise—but an increasingly powerful and affluent nation will be inhabited by growing numbers of presumably frustrated young men who find their life chances worsening in a most personal and bitter fashion. Their expectations will be shaped not by ancient Chinese history, but by marriage prospects within living memory. Will this make for millions of stories of quiet personal desperation or something more collective and convulsive: for anomie or fury? It is too early to tell. At the very least, however, we should regard China's future marriage squeeze as a potential wild card—possibly an important one.

**Domestic Migration, Urbanization, and the *Hukou* System**

Integral to the structural transformation of the Chinese economy during its extended spate of exceptionally rapid growth has been a reallocation of labor out of agriculture and into industry and services, and a corresponding movement of population out of the countryside and into the cities. Between 1978 and 2015, the population of what China officially defines as urban areas has grown by almost 600 million (roughly 200 million more than total national population growth) and the official urbanization ratio has more than tripled, catapulting from 18% to almost 56%.[30] The UNPD envisions a further increase of China's urban population of over 300 million between 2015 and 2040, at which point China would be over three fourths (76 percent) urban.[31] Chinese leadership is counting on urbanization as an engine of economic growth for the Chinese future and is attempting to accelerate the rise of cities through the aforementioned far-reaching "urbanization drive." Authorities in Beijing are right to regard cities as engines of growth—a corpus of economic research corroborates that judgment.[32] But "urbanization with Chinese characteristics" involves a population problem that does not show up in conventional "headcount" statistics. It relates to China's peculiar institution, the *hukou* system.

*Hukou* is a system for household registration and personal identification that traces far back into imperial China, but whose modern import derives from Mao's weaponizing it as a tool of totalitarian control. From the 1950s onward, the Chinese Ministry of Public Security has supervised *hukou* and designated the official place of residence of every Chinese citizen. It is illegal to live outside of ones authorized *hukou*—although temporary *hukou* can be approved in certain circumstances (for example, if one has found a job in a city or a different province).

Although Beijing relaxed its stringent controls on domestic migration in the early 1980s, to date the Chinese government has proved extremely reluctant to "update" workers' or migrants' *hukou* in accordance with their new place of residence. Thus an enormous "floating population" of out-of-*hukou* migrants has emerged with the rise of Chinese cities and the attendant upsurge in urban demand for labor. As of 2010, China officially numbers its floating population at around 220 million; about one fifth of all working age men and women were out-of-*hukou* then, and both the totals and proportions would be higher today.

Most of China's floating population today is comprised of migrant peasants working in urban areas. (Their *hukou*

identity papers ascribe that class status, by the way.) With very few exceptions, these men and women—and for that matter as well, the migrants who left their home towns and cities for other urban jobs—work in places where they are at best second-class citizens, at worst *de facto* illegal aliens. In their "temporary" residence, as a rule, they have no right to local services (health care, education etc.). They have no right to bring their (non-working) family members with them. Their compensation is lower than for in-*hukou* counterparts of the same education and skill levels. And in legal or other disputes involving authorities, they are virtually sure to lose.

Urban China desperately needs migrants—for reasons demographic as well as economic. Fertility levels are extremely low in Chinese urban areas, and extraordinarily low in China's bigger cities. In recent years total fertility rates in places like Beijing and Shanghai have sometimes been below 1.00—one birth per woman per lifetime. Overall, prolonged extraordinary sub-replacement fertility means that these places can no longer sustain their overall population totals, much less their labor forces, without a constant inflow of new migrants.

Thus the contradiction: cities (and economic planners) need new urban migrants—but those very same migrants must be treated as inferior beings by the logic of the current *hukou* population control system. The contradiction is highlighted in Figure 8, which depicts the population structure by *hukou* status of China's big cities (*shi*) as of 2010. [SEE FIGURE 8] In all, over 40 percent of the big city population that year was accounted for by migrants—and migrants comprised the outright majority of all big city residents in their late teens, twenties, and early thirties. Remember: the data in Figure 7 are now 8 years out of date—undoubtedly migrants form a majority of even more working age groups in China's larger cities today.[33]

Even within the Beijing dictatorship itself, the patent injustice of *hukou*-based exploitation of the new caste of migrant workers is widely recognized. Official and semiofficial discussion of *hukou* "reform" (meaning abolition) has been in the air for two decades and more. And some adjustments are underway: the official "urbanization drive" talks of granting local *hukou* to 13 million workers a year through at least 2020. But since urban population will be growing rapidly at the same time, such measures would merely more or less cap the size of the urban out-of-*hukou* contingent. If everything goes according to plan, in fact, 15% of China's total population will be "temporary urban residents" in 2020: over 200 million people. To judge by current indications, Chinese leadership intends to maintain the *hukou* system indefinitely.

But why? There are at least two obvious answers. First: under current arrangements, migrant workers are cash cows for the cites and townships in which they toil; vesting them with the same rights to services as in-*hukou* urbanites would throw public finances into disarray for municipalities across the country. The central government could fix this problem through budgetary consolidation relatively easily—but this would also be expensive, and Beijing does not want to assume these costs. Second: the *hukou* system still seems to be viewed by this police state as an indispensable instrument of control. Social and political stability in urban areas is a paramount concern for Chinese leadership (in part for historical reasons: dynasties fall when the capital and the major cities fall), and the *hukou* system helps assure public order in cities.[34] Recall that just a decade ago, during the global financial crisis of 2008/09, an untold number of million migrant workers (perhaps 20 million or more) were sent back home when export demand slumped; this mass resettlement was enforced via *hukou*. What would have happened if those unemployed masses had stayed in place, milling about in the cities? Chinese authorities didn't want to find out. That experience—and more recent exercises of *hukou* power for mass ejection of migrants (in Beijing for example)—have presumably demonstrated the utility of the *hukou* and reinforced the regime's determination to keep it in place.

In the *hukou* system we see a political problem in demographic form. It is akin to "influx control" under the old South Africa *apartheid* regimen; thanks to *hukou*, urban centers now look a bit like "Soweto with Chinese characteristics." We know what happened in Soweto. Until and unless the *hukou* system is genuinely reformed, China may have comparable tinderboxes in every one of its big cities. For this reason, migration and urbanization should be regarded as another "wild card" in China's future—and one whose risk of being cast could be considerably higher than the "marriage squeeze" card.

**The Coming Revolution in Family Structure**

One immensely important and utterly unstoppable demographic change now underway in China has attracted curiously little attention form Chinese policymakers and their think-tank advisers. This is the coming revolution in Chinese family structure. While the Chinse Academy of Social Sciences, DRC, and other organizations have provided voluminous analyses on coming labor force trends, the implications of population aging, urbanization, and migration, and even SRB gender imbalance, there has been so far as I can tell no research yet on mapping out the dimensions or examining the implications of the now unavoidable atrophy of the extended family, or the equally unavoidable rise of a "new family type" within China. Perhaps this is because such work would take us beyond "the headcount approach;" the Chinese government, like other modern states, collects demographic data on individuals and households, not kinship networks.

Changes in childbearing and survival patterns cannot help but change nuclear family and extended family patterns too—and dramatic changes in childbearing and survival lead to dramatic changes in family patterns. (For simplicity's sake we will be discussing only consanguineous family here—but that is not a bad first approximation for family in China today.) Generally speaking, improved survival increases the number of living family members and kin at any point across one's life course, while declining fertility has the opposite effect. But the distribution of births (the so called "parity progression ratio" or PPR) also matters: a society could have an average of two births per woman if half of all women had four children and half had none—and this would look very different from one where all women had exactly two children. China's tremendous improvements in life expectancy since the early 1950s greatly increased the number of living kin for grown men and women over the past three generations. But total potential living kin depend on birth patterns and of course fertility has plummeted in modern China.

Of particular interest in this regard is the number of only children in China, today and tomorrow. The rise of the only child radically transforms not only the structure of the nuclear family but also extended kinship networks. Both official Chinese and independently conducted reconstructions of PPRs indicate that almost all women of childbearing age got married and almost all had at least one child—but from around 1993 on fewer than half of first births led to further births for the country as a whole. In 1990, by these reckonings, about one in six Chinese births would end up only children; by 2000 the fraction would jump to two in five or perhaps even higher.

Calculations for the proportion of only children are highly sensitive to under-reporting of births, so it is possible that they overstate the nationwide proportions of only children in China. That said, there is no doubt whatever that only children have comprised a majority of newborns in urban China for decades. Whereas the national fertility level fell below replacement in the early 1990s, it appears to have dropped below replacement in urban China in the early 1970s, years before the One Child Policy; by 1982, in the early days of that population control drive, total fertility rates in urban areas were already down to an estimated 1.4 births per woman per lifetime.[35] By 1984 over half of all urban births (townships plus big cities) may have been only children—and in the big cities the ratio may have been closer to 70 percent. In the biggest metropolitan areas, the share of only children might be even higher. By collaborative estimates of the China National Statistics Bureau and the East West Center in Hawaii, four fifths of babies born in Shanghai were only children as early as 1990, with ratios for Beijing only slightly lower.

Today only children form a majority of urban China's (legal *hukou*) population under 35 years of age—and a supermajority of the under-35 population in the country's big cities. This means we are starting to see the rise of a new family type in China: only children begotten by only children—boys and girls with no siblings, cousins, uncles, or aunts, only ancestors and (perhaps eventually) descendants. For this new family type, the traditional extended family has essentially collapsed. This new family type is now beginning to account for a sizeable fraction of urban China's (officially authorized resident) children—very possibly, an outright majority in the country's economic and political nerve centers (Shanghai and Beijing) and in other cities of size as well. But even in places where the emerging new family type does not dominate, in the rising generation who will be the parents of 2040, the extended family and its kinship networks are being dramatically compressed by long-term sub-replacement fertility.

The family unit matters everywhere, but it has assumed a particularly prominent institutional and even spiritual role in Chinese tradition. For millennia *guanxi* networks—comprised principally though not exclusively of fellow clansmen—have helped provide financial and human security for the Chinese population; they have been integral to getting business done at the micro level, and at the macro level have improved national economic performance by reducing transaction costs and risk. What will happen to economic performance in China as its *guanxi* networks come under extraordinary new demographic pressure? We are about to find out. There are of course functional substitutes of sorts for family-based *guanxi* networks: deep personal friendships among unrelated individuals would be one; impersonal spheres of "social trust" now witnessed in China's fascinating "fintech revolution" would be another. But it is far from clear that these substitutes are complete substitutes, much less perfect ones.

The ongoing family revolution in China might possibly also have implications for political cohesion and national security. Remember the tragic Sichuan earthquake a decade ago, in which thousands of schoolchildren perished. Many of them were only children; their deaths brought a permanent end to untold family lineages. In those localities and across China there was a spasm of social rage as people learned that the earthquake knocked down cheap and shoddily constructed schools, even though nearby CCP and government buildings survived the tremors. The tragedy took on an electrifying import across China, one magnified by its consonance with the age-old Chinese theme of unjust rulers losing the mandate of heaven. This disaster was thus also a public relations disaster, and forced the regime into contrition mode, requiring the unusual spectacle of conspicuous and repeated public apologies by Chinese officialdom, all the way to the very top.

Consider what this domestic tragedy may portend for a future international confrontation or conflict involving

serious Chinese casualties. Many of the soldiers in the PLA will presumably be only children. Major losses would mean the end of a great many family lines. If China suffers setbacks in international military operations, or if the Chinese public deems these losses to be the result of an illegitimate use of power, what sort of explosion of social rage might Beijing face? (No less pertinent: how might regime calculations about the *possible risk* of social rage due to military losses condition China's defense strategy and tactics in the years ahead?)

**Concluding Observations**

Demographic factors suggest, among other things, that the coming generation will not see a repeat performance of the phenomenal economic rise that China enjoyed over the past generation (or generation and a half). To be sure: despite the demographic constraints outlined above, China is certainly capable of generating creditable rates of economic growth for the foreseeable future. But demographic realities (among other forces) are likely to bring an end to China's era of "heroic economic growth," possibly sooner rather than later. Utilizing a human capital-based model, Stanford's Scott Rozelle and colleagues have ventured that the Chinese economy would grow by an average of 3% per annum over the coming 20 years.[36] In my own current work, a simple human-resources-plus-business-climate model comes up with results more or less consistent with Rozelle et al: about 2.5% per annum GDP growth for the 2025-40 period when GDP is measured in PPP terms (with somewhat higher rates for exchange-rate based GDP).[37] We should recognize that such projections are lower than most prevailing estimates—but they highlight the headwinds the Chinese economy faces when demographic trends are taken into consideration.

Demographic constraints could also complicate Beijing's quest to mobilize political power and/or apply it abroad. At this writing the Chinese regime seems to be behaving in an increasingly ambitious and assertive fashion: the era of "hide your strength, bide your time" appears to be over. Demographic stresses could reduce social cohesion, or even contribute to social or political instability. Note the verb "could": this is by no means a certainty. But it is a possibility that would be unwise to ignore. Dynasties in China always end. When and how the current regime will end, and whether demographic forces will play any appreciable role in its demise, will only be known in the fullness of time. In any event, over the next generation that regime must cope not only with the "marriage squeeze" and the "floating population" problem but with an upending of an extended family system that is as old as Chinese civilization itself. It is still difficult for us to imagine what China will look like, much less how things will work, with the rise of the "new family type." We cannot yet dismiss out of hand the conjecture that this development could prove to be an existential, civilization-challenging event.

Finally: there is the question of China's long-term fertility trends, and what the government may do to affect these. This question is not too pertinent to the demographic outlook for the year 2040, as we have already seen, but it is highly relevant to speculation about China 2050 and beyond.

It is important to recognize that the regime still holds the national birth rate to be a matter of state, not of parental choice. The adjustments to the population policy in recent years did not vitiate the regime's claim for itself to the right to set national fertility levels—it merely raised the birth quotas the government would permit.

Now there are hints that Beijing may be toying with a population policy U-turn, a 180-degree shift to a pro-natal population policy. Some have noted, for example, this year's new Lunar New Year postage stamps, featuring a cartoon of five happy pigs—two parents and their three children. Little signals like this are sometimes leading indicators for new political campaigns.

Absent government pressure, China's "natural" fertility trajectory might well be further decline: after all, fertility levels today are decidedly lower than China's in neighboring Hong Kong, Taiwan, South Korea, and Japan. They are lower in authoritarian Singapore too, despite that nation-state's attempts to encourage births through three decades of pro-natal measures.

Could Beijing succeed where Singapore has failed? Police state power may be effective in forcing births down—but could it also force births up? In the 1960s, Communist Romania banned suddenly abortion without notice and doubled the nation's birth rate the following year—but that was a one-off, and birth rates gradually returned to the abortion-era levels.

Beijing may have more sophisticated, and intrusive, tools at hand for any future pro-natal campaign. "Social media credit ratings" through fintech could be one of these: far-reaching financial penalties for those evidencing unpatriotic tendencies, including childlessness. Think of it as "market totalitarianism." To date pro-natal policies around the world have met with at best limited success. But then again none yet have experimented with "market totalitarianism."

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[1] American Enterprise Institute eberstadt@aei.org. The author would like to thank Cecilia Joy Perez for research assistance and valuable suggestions on this paper. The usual caveats apply.

[2] Population projections lose their reliability when demographers begin to make guesses about how many babies the currently unborn are going to bear. There is no reliable basis for such projections today—and as long as human births are a matter of future individual volition, there presumably never can be. If we

try to look more than a generation ahead for any population, we are thus getting into the realm of science fiction.

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[31] UNPD, "World Urbanization Prospects - Population Division," *United Nations*, accessed September 24, 2018, https://population.un.org/wup/.

[32] Edward L. Glaeser, *Triumph of the City*: *How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier* (New York: Penguin Press, 2012), https://www.penguinrandomhouse.com/books/303439/triumph-of-the-city-by-edward-glaeser/9780143120544/

[33] These are data from China's 2010 census as officially reported. We know that UNPD believes the nation-wide figures involved an undercount of about 30 million—but since most of that undercount is thought to have been rural, this should not distract us here.

[34] Jeremy L. Wallace, *Cities and Stability*: *Urbanization, Redistribution, and Regime Survival in China* (Oxford University Press, 2014), http://www.oupcanada.com/catalog/9780199378982.html .

[35] Guo, Z., Wu, Z., Schimmele, C., & Li, S, "The Effect of Urbanization on China's Fertility," *Population Research and Policy Review*, 31(3), 417-434 (2012), http://paa2012.princeton.edu/papers/120365 .

[36] Li, Hongbin, Prashant Loyalka, Scott Rozelle, and Binzhen Wu. "Human Capital and China's Future Growth." *The Journal of Economic Perspectives* 31, no. 1 (2017): 25-47. https://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.31.1.25 .

[37] Nicholas Eberstadt's ongoing research for the Office of Net Assessment/Office of the Secretary of Defense contributed to this essay.

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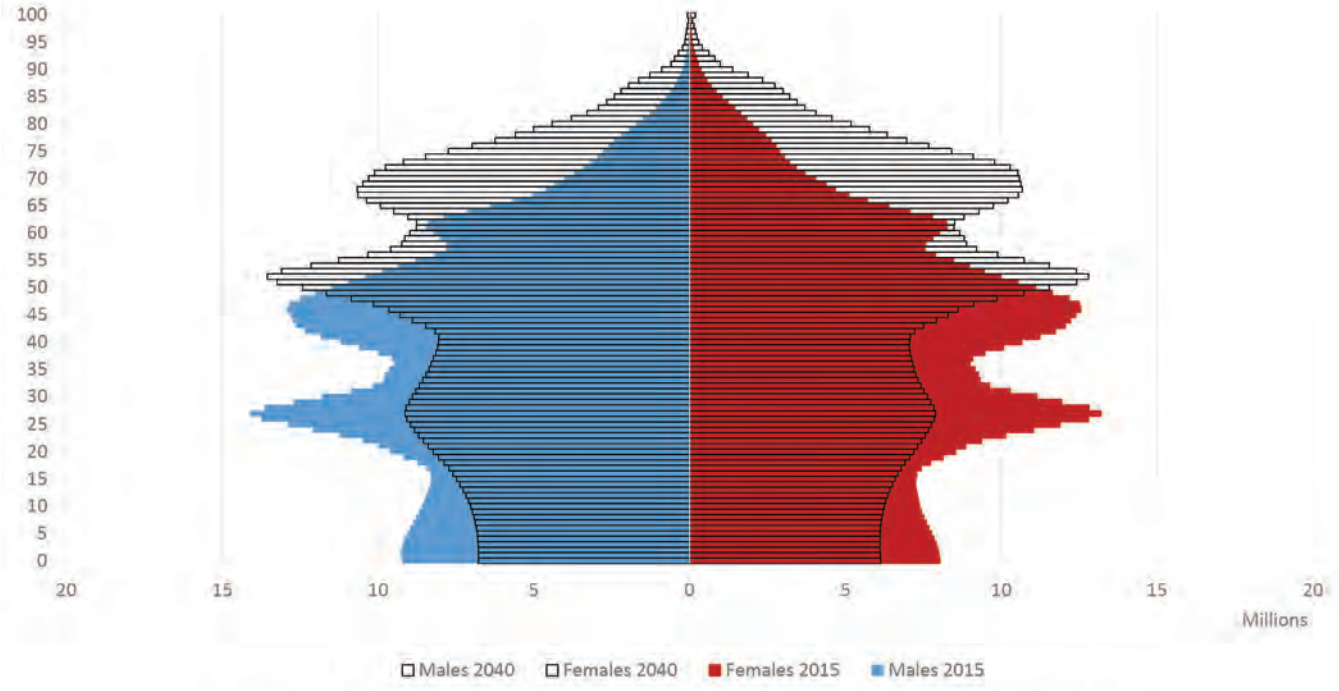
# Supporting Data

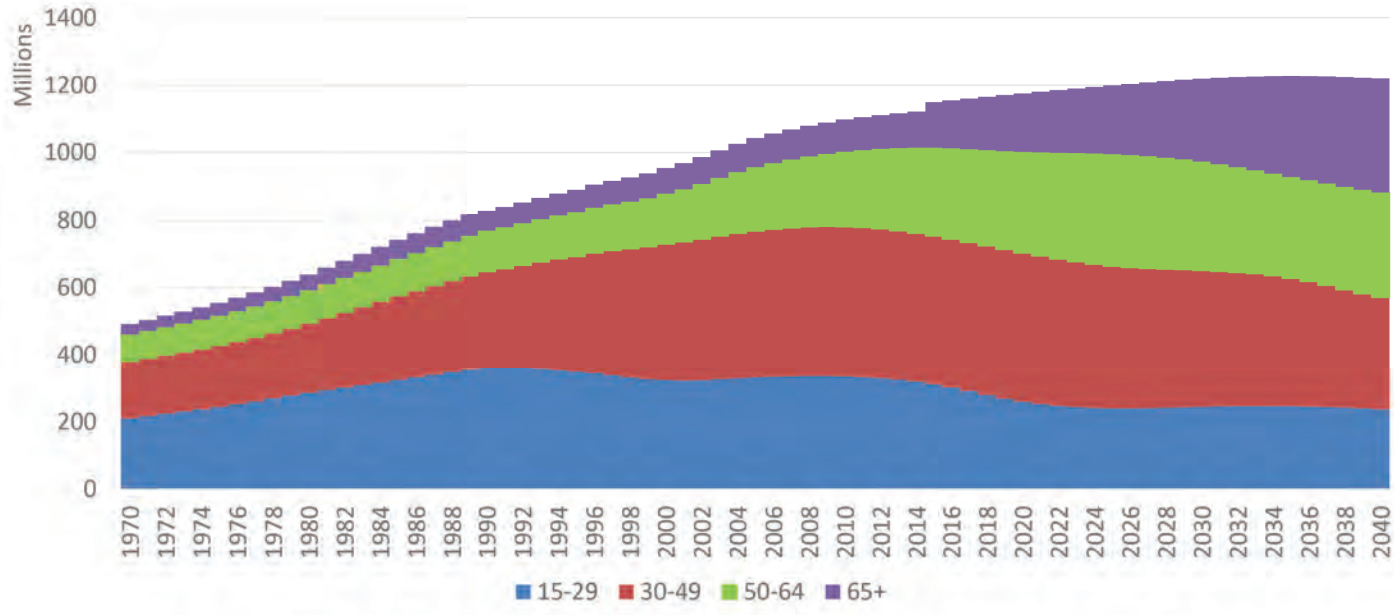
**Figure 1**
China's Population Structure: 2015 vs. 2040
UN Population Division Estimates and Projections (medium variant)




Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2017 Revision*, http://esa.un.org/unpd/wpp/index.htm, accessed on September 18th, 2018.

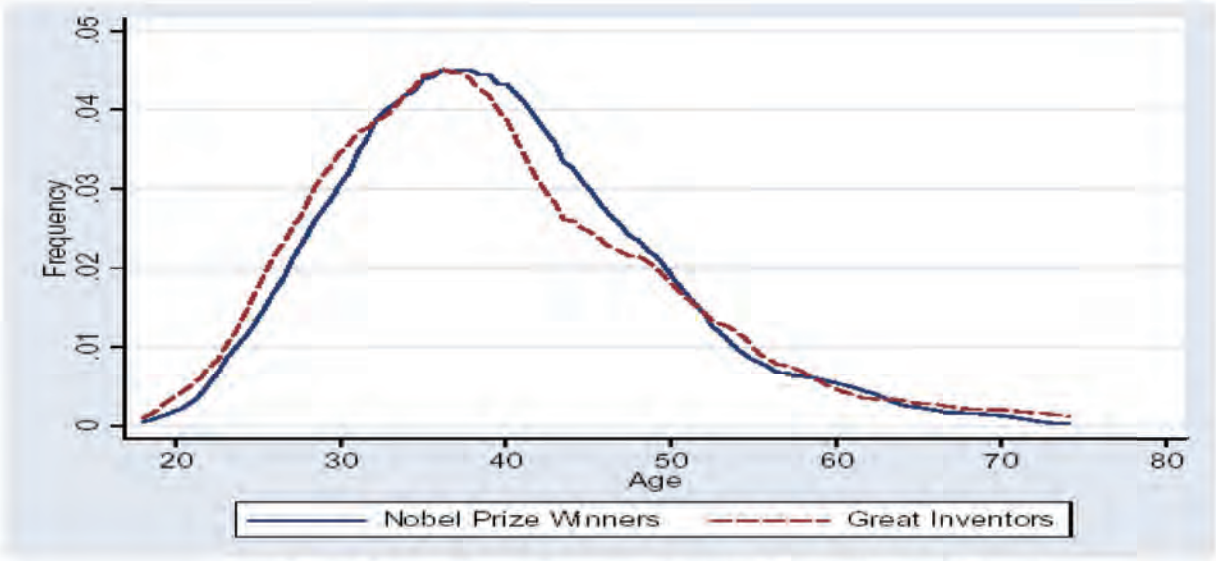


**Figure 2**
Adult Population 15+ by Age Group: China, 1970-2040
(estimated and projected, million)



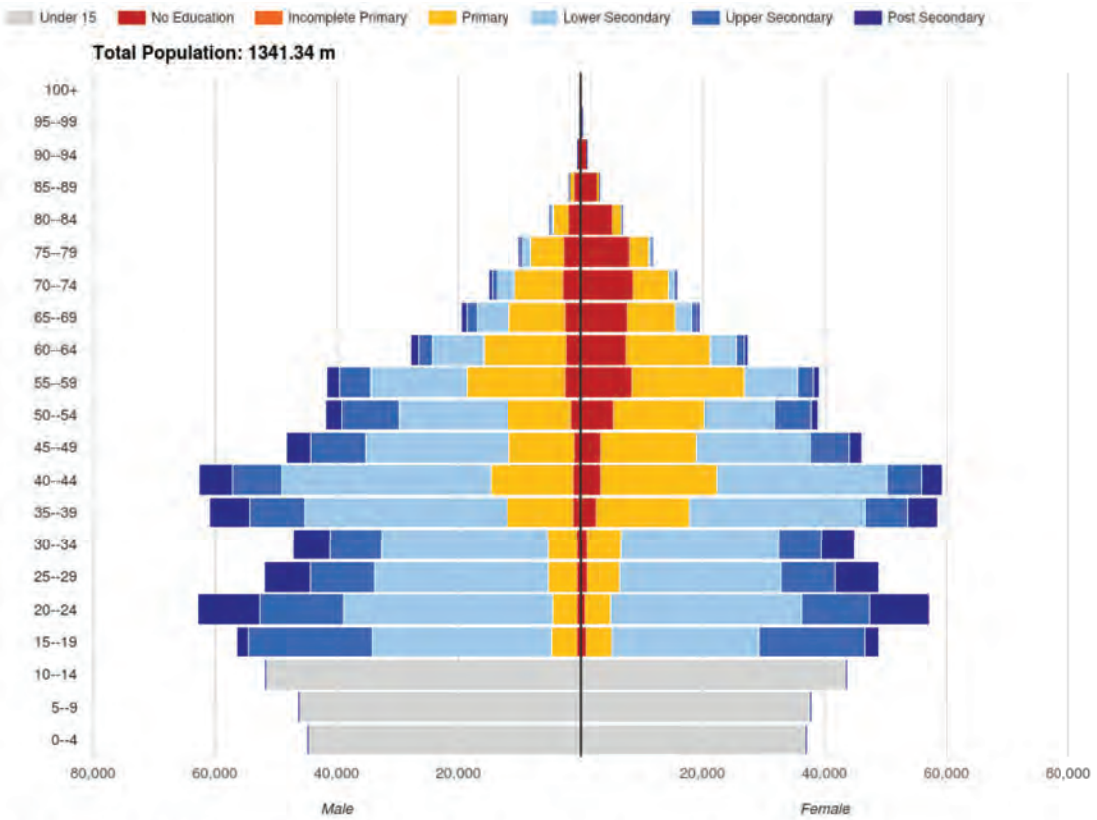

Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2017 Revision*, http://esa.un.org/unpd/wpp/index.htm, accessed on September 18th, 2018.

**Figure 3**
The Age Distribution of Great Innovation in the 20thCentury




Benjamin F. Jones, "Age and Great Invention" (Working Paper 11359, National Bureau of Economic Research, May 2005), http://www.nber.org/papers/11359 (accessed July 2, 2007).

**Figure 4**
China population structure by educational attainment, 2010 (estimated)




Source: Wittgenstein Centre for Demography and Global Human Capital, (2015). *Wittgenstein Centre Data Explorer Version 1.2.* Available at: www.wittgensteincentre.org/dataexplorer.

Population (000's) Pyramid
China
2010
Medium (SSP2)

R version 3.1.2 (2014-10-31) • Google Terms of Use • Data Policy: See individual charts

**Figure 5**
China population structure by educational attainment, 2040 (projected)

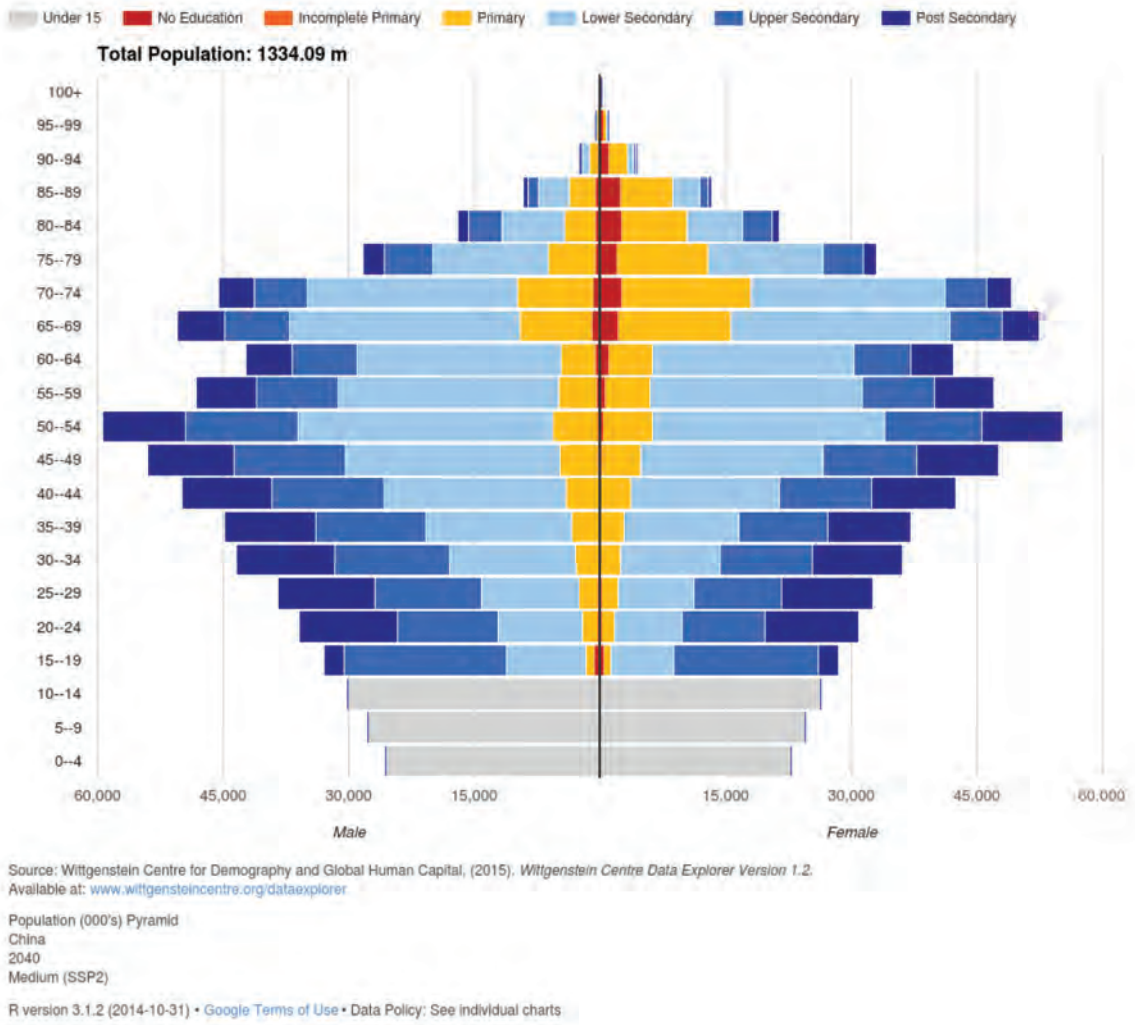
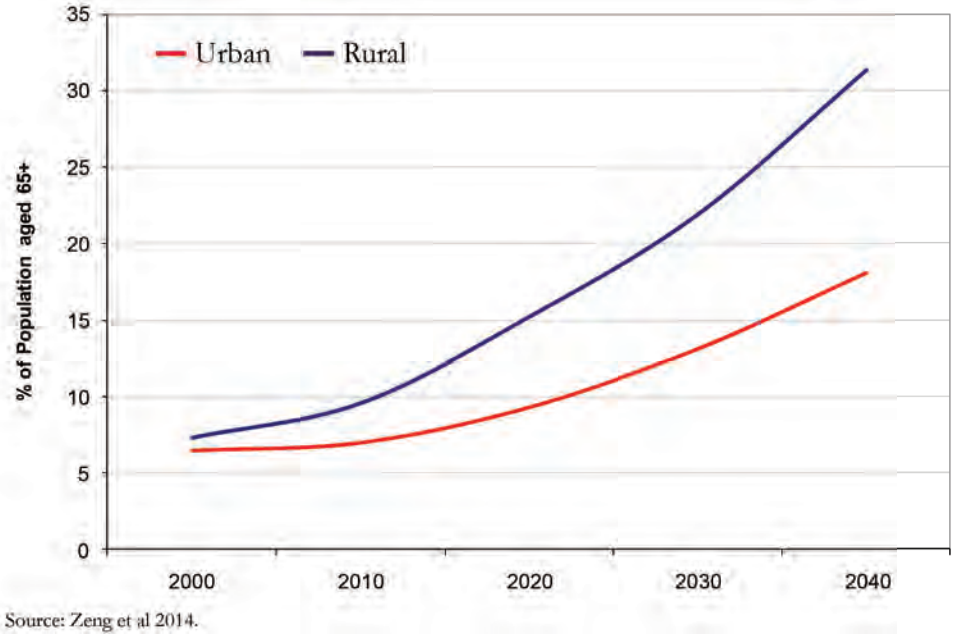



**Figure 6**
Projected percentage population 65+: Urban and rural China, 2000-2040




Source: Zeng et al 2014.

**Figure 7**
Proportion of never-married males by age group:
China 2000-2030 (projected per Zeng et al)

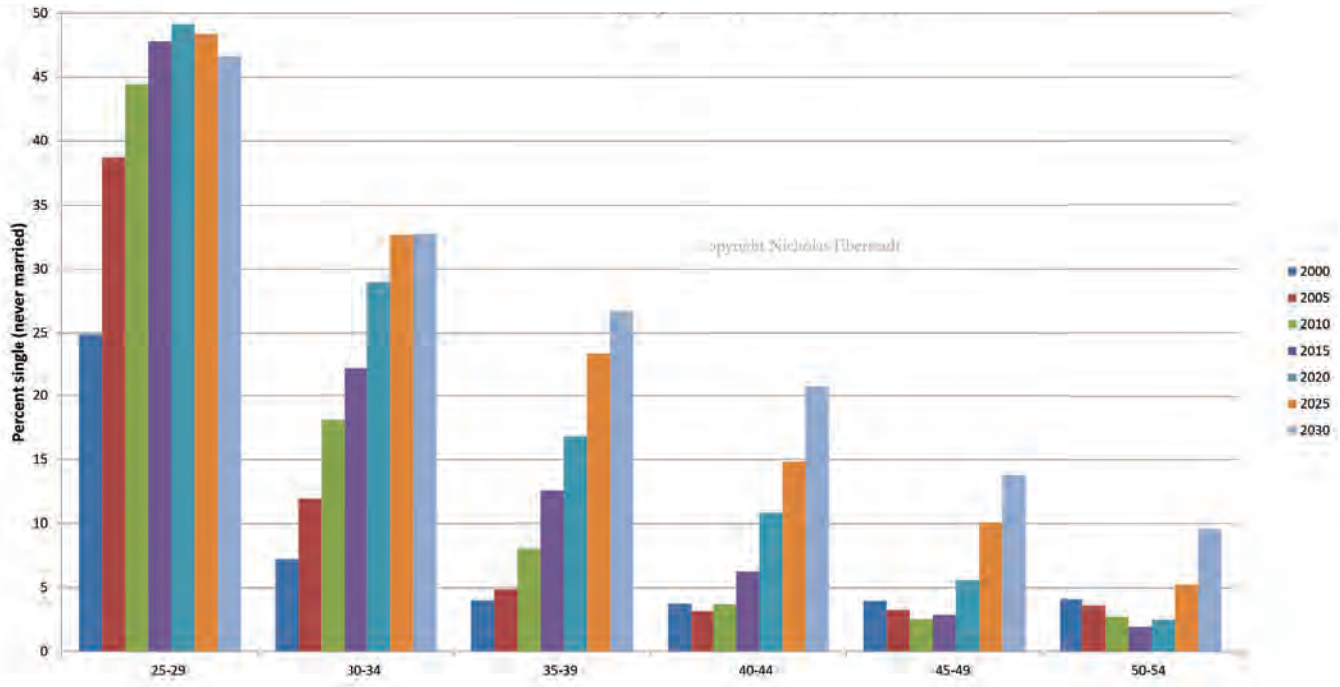
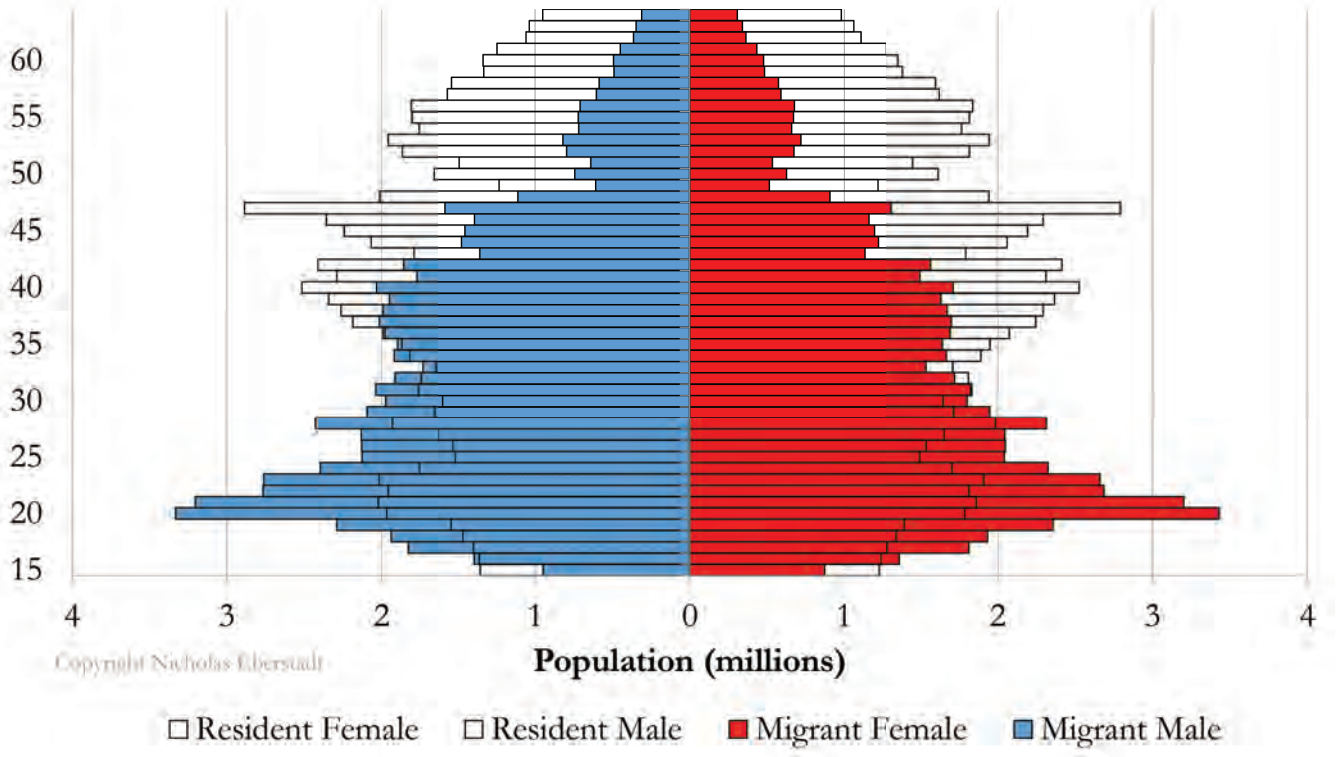



**Figure 8**
Resident vs. Migrant:
Reported Composition of Working-Age (15-64)
Manpower, China (City), 2010




Source: Department of Population and Employment Statistics National Bureau of Statistics, "China Population Census: Tabulation of the 2010 Population Census of the People's Republic of China" (Beijing: China Statistics Press, 2012).

# The AI Titans' Security Dilemmas

**By Elsa B. Kania,** Center for a New American Security

As China and the United States enter a new era, in which rivalry and confrontation are starting to extend across all dimensions of this bilateral relationship, artificial intelligence (AI) has emerged as a new frontier of strategic competition. Evidently, nations worldwide recognize the strategic significance of AI technologies to the future of economic development and military modernization. As such, it is hardly surprising that the United States and China have prioritized AI, though taking quite different approaches to policy. In the process, reactions to and perceptions of each other's advances and ambitions have been a key influence upon these efforts. For instance, the Chinese government's decision to devote strong state support to AI development was catalyzed to some extent by concerns over the perceived superiority of 'Western' AI, as demonstrated by AlphaGo's mastery of the game of Go in the spring of 2016. The initial steps taken towards a U.S. national strategy on AI around that time also appear to have heightened Beijing's concerns about the risks of falling behind in these technologies.[1] China has since formulated and actively implemented the New Generation Artificial Intelligence Development Plan (新一代人工智能发展规划), released in July 2017, which articulated the objective for China to "lead the world" in AI by 2030.[2] Increasingly, U.S. concerns over China's emergence as an AI powerhouse—and would-be "AI superpower"[3]—have influenced calls for an American strategy for AI, towards which critical progress has occurred with the launch of the American AI initiative in February 2019.[4] Increasingly, AI seems to be front and center in today's great power competition.[5]

This tendency towards U.S.-China AI rivalry is not inherently problematic, insofar as competition can act as an impetus to spur advances in technologies that can create significant advantages and opportunities to enhance human well-being. Moreover, competition in this context is not purely bilateral, nor is it the defining feature of this relationship, given the opportunities for continued cooperation between the U.S. and China. Thus far, some of the leading players in AI have been tech companies with global presence and interests. Chinese and American companies and universities have often engaged and collaborated, including new partnerships announced in 2018 between MIT and Chinese AI start-ups iFlytek and Sensetime.[6] Beyond the United States and China, a range of nations worldwide, from Russia to Japan and the European Union, are launching their own AI policies and strategies.[7] In some respects, smaller states and non-state actors might even have an advantage in AI, if proving more agile and creative in taking advantage of its applications.[8] However, against the backdrop of a severe, and seemingly worsening, U.S.-China security dilemma, which is exacerbated by mistrust and misperception,[9] there are risks that this tendency towards competition could exacerbate arms racing dynamics in the military applications of AI, perhaps resulting in troubling compromises on the safety and surety of these technologies. Indeed, as the United States and Chinese militaries seek new opportunities to achieve a disruptive, or even decisive, advantage, their apparent enthusiasm for the potential of AI in national security and defense might, at worst, result in new threats to strategic stability. This paper explores the impetus, objectives, and indicators for advances in China's quest to advance an agenda for military "intelligentization" (智能化) in comparative perspective, while highlighting likely risks and potential challenges that may adversely impact future strategic stability in this complex, consequential relationship going forward.[10]

**Chinese Military Innovation and "Intelligentization"**

China's reaction to the U.S. Third Offset Strategy has shaped the prioritization of military innovation by the People's Liberation Army (PLA) under the leadership of Xi Jinping. In recent history, the PLA has often focused on 'learning without fighting,'[11] through a close study of U.S. ways of warfare and attempts to draw lessons from other militaries' experiences, seeking to compensate for its own lack of recent combat experience.[12] Unsurprisingly, PLA academics and strategists have closely tracked the Third Offset since its inception, particularly given the potential implications of this strategy for the future military balance.[13] Indeed, U.S. defense leaders decided to undertake the Third Offset strategy in reaction to concerns that great power rivals, namely China and Russia, were starting to emerge as true near-peer competitors, including through their development of better battle networks, i.e., command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) systems, along with what U.S. military planners have characterized as Anti-Access/Area Denial (A2/AD) capabilities.[14] Consequently, the Department of Defense

has sought new opportunities to regain advantage at the operational level of warfare, drawing upon the legacy of prior "offsets"—including the "first offset" of nuclear weapons and the "second offset," which involved the introduction of stealth, precision strike, and battle networks.[15] At the core of this strategy was a focus on the potential of emerging capabilities—including learning systems, human-machine collaboration and combat teaming, and network-enabled and cyber-hardened autonomous weapons.[16] These U.S. concepts and initiatives have evidently intensified China's own quest to advance new directions in its military modernization.

Xi Jinping has highlighted the imperative of an "innovation-driven" strategy for China's development, while calling upon the PLA to advance military innovation.[17] This strategic approach is motivated by an assessment of trends in the global Revolution in Military Affairs (RMA),[18] characterized by advances in long-range, precise, smart, stealthy, and unmanned weapons, as highlighted in the defense white paper on "China's Military Strategy."[19] The PLA's commitment to military innovation includes not only technological advancement but also the formulation of new theories, concepts of operations, and organizational approaches.[20] These ambitions must be recognized as the continuation of a decadal process of modernization, through which the PLA has sought to transform itself from a force that was once scarcely mechanized to one that is becoming truly "informatized" (信息化)—and ever more capable, in the words of Xi Jinping, of "fighting and winning" wars. Indeed, the "China Dream" of "national rejuvenation" includes the objective of a powerful military (强军目标) capable of defending China's core and national interests, which are expanding globally in their scope and scale.[21] Presently, the PLA is undertaking historic reforms and reorganization that could increase its capabilities for joint operations. The PLA is also concentrating on the development of "new-type forces" and "new concept" weapons, from the construction of the Strategic Support Force, which has integrated and consolidated space, cyber, electronic, and psychological warfare capabilities,[22] to the advancement of hypersonic weapons systems.[23]

Xi Jinping's call to "Accelerate the development of military intelligentization" in his remarks during the 19th Party Congress in October 2017, has placed official imprimatur upon the leveraging of AI to enhance future military power.[24] This concept, which extends and builds upon the PLA's prior strategy of informatization, could emerge as a new principle guiding the future trajectory of Chinese military modernization, which is increasingly advancing a range of applications of AI and related technologies. As characterized by a number of Chinese defense academics and strategists, this concept does not merely imply the militarization of AI,[25] but also seems to involve and require related advances in theories and training for future operations, as well as the related materials and supporting infrastructure.[26] According to a PLA scholar from the National University of Defense Technology, "military intelligentization refers to the overall operational description of the forces system of systems consisting of people, weapons equipment, and ways of combat." In practice, such a system of systems would involve not only intelligent weaponry but also concepts of human-machine integration (人机一体) and intelligence leading (智能主导).[27] In practice, the PLA's agenda for intelligentization may prove quite expansive, extending across all concepts in which AI might have military relevance in enabling and enhancing war-fighting capabilities, from logistics to early warning and intelligence, military wargaming, and command decision-making.[28]

The PLA's traditional emphasis on asymmetric capabilities, often referred to as "assassin's mace" or "trump card" weapons (杀手锏), could influence its approach to these emerging technologies. For instance, the Chinese military and defense industry have concentrated on the development of swarms of drones and even of ships, recognizing their potential to overwhelm the defenses of an adversary's valuable weapons platforms.[29] At present, a majority of these capabilities remains at various stages in research, development, and experimentation, and it is difficult to evaluate their sophistication based on appearance or announcements alone.[30] Looking forward, Lieutenant General Liu Guozhi, director of the Central Military Commission's Science and Technology Commission, has emphasized the imperative of advancing military intelligentization, arguing, "this is a rare strategic opportunity for our nation to achieve innovation leapfrogging."[31] At present, however, many of the technologies in question remain relatively immature, pending future testing and verification. In this regard, the realization of this agenda for military innovation will play out for years to come. It is too soon to evaluate with confidence whether the PLA will prove successful in achieving these aspirations to surpass or leapfrog ahead of the U.S. military.

**Initial Progress and Challenges**

The PLA is actively supporting a range of projects and research activities involving military applications of artificial intelligence and related technologies. Within the PLA, the Central Military Commission (CMC) Science and Technology Commission (S&TC) is taking the lead in advancing military-technological innovation, including through a plan focused on "frontier innovation" (前沿创新). Concurrently, the CMC Equipment Development Department (EDD) has created an AI Expert Group that may guide and direct the advancement of AI-enabled armaments. There are a variety of funding mechanisms through which the PLA is supporting dual-use and military

research across the defense industry, technology companies, and universities. For instance, a fund focused on naval innovation has funded the development of AI-enabled image processing and target recognition technologies, including to detect ships in satellite imagery, while the EDD has also supported research on the use of machine learning, and specifically deep learning, for the analysis of underwater acoustic signals.[32] It is worth noting that research on these and other applications of AI often reflects a history that extends beyond the recent emphasis on and enthusiasm for these technologies, even dating back to the 863 Plan that supported early AI-related research from the late 1980s onward.[33] Gradually, a more robust and diverse innovation ecosystem is emerging across PLA research institutes, the Chinese defense industry, and a growing number of private companies, from smaller start-ups, such as Yunzhou-Tech, to 'national champions' like Baidu, which is clearly at the forefront of China's AI revolution.[34]

In the near future, certain of the promising applications of these technologies will involve enabling capabilities that reflect more 'qualitative' augmentation of existing systems, often in ways that may be difficult to discern readily from observable indicators. For instance, there has also been apparent progress in research involving the AI-enabled mining and processing of data from remote sensing satellites, which may already be in use, at least to a limited degree, by the PLA Rocket Force and Strategic Support Force.[35] Recognizing the criticality of data fusion and intelligence to future operational advantage, PLA researchers are also exploring options to leverage AI technologies to train on and learn from target features acquired by a range of sensors.[36] For instance, the application of machine learning to improve automatic target recognition (ATR), including with the use of convolutional neural networks in Synthetic Aperture Radar (SAR) image target recognition, is recognized as an opportunity to build upon prior research to enhance the precision in targeting.[37, 38] As virtual domains emerge as critical frontiers of military competition, the PLA's interest in "cognitive electronic warfare," influenced in part by concern over U.S. efforts, reflects a recognition of the potential impact of applications of machine learning to enable more adaptive countermeasures to seize dominance in the electromagnetic spectrum.[39] So too, given the threats of such countermeasures, Chinese researchers are also focusing on ways in which AI can bolster the resilience of future communications networks against an adversary's attempted jamming and interference.[40] Considering new threats and confrontation in cyberspace, the potential of AI to enhance cyber security, defense, and perhaps also offensive operations may also emerge as a major priority for China under the PLA Strategic Support Force.

Anticipating a trend towards future "unmanned" warfare, the PLA is rapidly advancing the development of new capabilities for greater 'intelligence' and autonomy across all domains.[41] The PLA Navy is deploying and experimenting with a range of intelligent/autonomous surface vessels and underwater vehicles.[42] Notably, the *Haiyi* (海翼) or "Sea Wing," an underwater glider designed by the Chinese Academy of Sciences (CAS) Shenyang Institute for Automation, used so far for scientific missions in the South China Sea,[43] has also been highlighted as having potential military utility, including due to its low acoustic signature.[44] The *Haiyi* could be leveraged to enable the detection of foreign submarines, thus potentially enhancing to enhance PLA anti-submarine warfare capabilities.[45] In addition, the *Jinghai* (精海), an 'intelligent' vessel with the reported capability to navigate autonomously, appears to be in use with the PLAN and might support maritime sensing and domain awareness.[46] As Chinese defense industry players, such as the China Shipbuilding Industry Corporation (CSIC), and even private sector contenders, such as Yunzhou-Tech, which is recognized for its significant contributions to military-civil fusion, develop a wide array of models and designs,[47] China has also established the world's largest facility for the testing of such vessels, including those optimized for combat missions, at the Wanshan Marine Test Site in Zhuhai.[48] The Chinese defense industry is also developing a range of USVs that could be employed for combat in support of the PLAN.[49] Reportedly, the PLA is also developing AI-enabled submarines to advance Chinese capabilities in undersea warfare, through a classified military program known as the 912 Project, which was disclosed in English-language reporting, perhaps a deliberate signaling of potential future capabilities.[50] Although fully autonomous submarines may remain a long-term objective, the introduction of AI technologies for decision support on submarines could prove more feasible in the meantime.[51]

The PLA's apparent enthusiasm for the disruptive potential of swarming capabilities has been manifest in multiple demonstrations featured prominently in official media. Notably, the China Electronics Technology Group (CETC), a leading state-owned defense conglomerate, has tested swarms of 67, 119, and then 200 fixed-wing UAVs, which have engaged demonstrated complex formations, setting this latest record in May 2018.[52] (Ehang, a UAV company, has even demonstrated a swarm of 1,374 drones in total, breaking the Guinness World Record.[53]) The PLA's National University of Defense Technology (NUDT) has also developed and demonstrated swarms of UAVs through its Academy of Intelligence Sciences.[54] Meanwhile, the PLA Air Force has organized a swarm challenge for the development of swarms with greater degrees of autonomy, capable of collaboration and coordination.[55] These intelligent unmanned systems could serve as an asymmetric

means through which to target high-value U.S. weapons platforms, including fighter jets or aircraft carriers. Of note, China's Military Museum includes in an exhibit on future warfare a depiction of a UAV swarm combat system (无人机蜂群作战系统) with swarms used for reconnaissance, jamming, and "swarm assault" (群打击) targeting an aircraft carrier, in conjunction with manned aircraft.[56] Chinese official reporting has also highlighted the successful testing of a 'shark swarm' of drone vessels, developed by Yunzhou-Tech, that could be acquired by the PLA Navy for future combat scenarios.[57] While swarms today range from dozens to hundreds in size typically, continued advances in commercial technologies, including cheap drones and more advanced techniques for additive manufacturing, could enable the scaling up of such swarming capabilities, perhaps even to include thousands of drones.[58] Of course, size alone is not a reliable indicator of capability in this context, and the true level of autonomy and sophistication of these swarms is difficult to determine by observation alone.

Looking forward, the PLA anticipates that the advent of AI in warfare could augment future command decision-making, potentially enabling new opportunities to achieve decision superiority relative to an adversary.[59] In an authoritative commentary, the CMC Joint Staff Department has called for the PLA to accelerate its construction of a joint operations command system through progress toward intelligentized command decision-making that takes advantage of the potential of AI, as well as big data, cloud computing, and other advanced technologies.[60] The Joint Staff Department's commentary highlighted that the victory of Google's AlphaGo in that "human-machine war" demonstrated the tremendous potential of AI in operational command, military war-gaming, and support to decision-making.[61] The introduction of AI to augment a commander's capabilities is expected to help compensate for human shortcomings and to enable speed and superiority in future decision-making.[62] According to PLA strategists, this introduction of AI into the realm of command decision-making may prove inevitable, and future warfare will involve the combination of intelligentized combat and command platforms,[63] with "intelligence dominance" (制智权) emerging as the core mechanism for victory.[64] In the foreseeable future, the PLA might leverage AI technologies to enhance the decision-making of fighter pilots or the commanders of submarines. According to credible reporting, there is a project underway to update the computer systems on PLAN nuclear submarines with an AI decision-support system in order reduce commanding officers' workload and mental burden.[65, 66] Through these efforts, AI may take on certain "thinking" functions on nuclear submarines, which could include, at a basic level, interpreting and answering signals picked up by sonar, such as through the use of convolutional neural networks.[67] As the PLA looks to promote innovation in 'actual combat' (实战) training, the use of AI to enhance the realism and sophistication of training methods may also emerge as a priority.[68]

Pursuant to national strategy of military-civil fusion (军民融合), China seeks to create and leverage critical synergies among academic, defense, and commercial developments in AI technologies. Increasingly, a range of incentives and partnerships have been introduced to advance this strategy, influenced not only by a long history in China's thinking on mobilizing resources for technological development but also by a close study of the successes of American defense innovation. While this agenda is increasingly expansive in scope and scale, a key metric of success will be China's capability to mobilize leading companies and universities in support of this agenda, taking advantage of their capabilities to promote dual-use technological developments. For instance, Baidu and CETC's 28th Research Institute have established the Joint Laboratory for Intelligent Command and Control Technologies, which will focus on increasing the level of 'intelligentization' in command information systems through incorporating big data, artificial intelligence, and cloud computing.[69] Notably, Tsinghua University, often characterized as 'China's MIT,' is strongly and institutionally committed to military-civil fusion and to supporting the advancement of Chinese military applications of AI. Tsinghua Vice President You Zheng has highlighted research underway on project on future human-machine cooperative (combat) operations.[70] Tsinghua is also building the "High-End Laboratory for Military (Artificial) Intelligence" with support from the PLA's Central Military Commission,[71] along with the Military-Civil Fusion National Defense Peak Technologies Laboratory, which will create a platform for the pursuit of dual-use applications of emerging technologies.[72] In the latest meeting of a commission on the topic, Xi Jinping called for the PLA to undertake more competitive approaches to procurement.[73]

Of course, the PLA's capability to operationalize this agenda of military intelligentization will be shaped and may be constrained by challenges of talent recruitment, new directions in training, and organizational adaptation.[74] That is, the development and deployment of AI require the recruitment of researchers and more proficient personnel into the Chinese defense industry and military. For instance, CETC, which has launched its own plan dedicated to AI development, has recruited for researchers with experience in artificial intelligence and machine learning.[75] The PLA's current reforms to its system for civilian personnel, which could facilitate the hiring of civilian scientists into military positions with benefits on par with the civil service, may contribute to its future human capital ecosystem. For instance, the PLA Strategic Support Force is currently recruiting a number of researchers with a background in AI, including for positions in "aerospace

artificial intelligence."[76] Of course, the ability to attract capable candidates will be inherently challenging, given the apparent shortfall in AI talent in China at present and competition with a dynamic tech sector. However, PLA universities are expanding their own educational opportunities in AI. For instance, the National University of Defense Technology (NUDT) has launched the Academy of Intelligent Sciences and evidently constitutes a key center of excellence for AI education and development within the PLA.[77] As AI is introduced into Chinese universities as a first-level discipline, and as the Ministry of Education implements a new plan to expand the offering of AI as a major and AI research institutes, this pipeline may further expand.[78]

As the PLA introduces more complex automated, autonomous, and otherwise 'intelligentized' technologies, the challenges for training could increase, including due to requirements for greater technical proficiency. However, there may also be some cases in which the PLA's current lack of experience and apparent shortcomings may motivate a more rapid adoption of 'unmanned' technologies. Notably, the CH-7 stealth UAV, revealed at the Zhuhai Airshow in the fall of 2018, has provoked speculation that the PLA Navy may be the first to introduce unmanned carrier aviation.[79] Such a potential leapfrogging that could reflect a response to and recognition of its lack of experience in manned carrier aviation.[80] The PLA's apparent enthusiasm for unmanned technologies, which has been less visibly hindered by a preference for manned aviation that other militaries seem to display, is reflected in portrayals of PLA UAV pilots, who are often lionized in PLA media.[81] Although there has been an expectation that authoritarian regimes may neglect the essential human element in future warfare, the PLA academics and strategists have, in fact, emphasized the importance of human intelligence and called for advances in intelligentized training in order to prepare personnel for the demands of future intelligentized operations,[82] including to improve human-machine cooperative (人机协同) decision-making capabilities.[83] However, certain PLA thinkers also anticipate that warfare may evolve and training must adapt from humans "in the loop" to "on the loop" to "outside the loop," guided by a focus on "human-machine interactive thinking" (智能化人机互动思维).[84] Although human-machine cooperation may be the trend in intelligentized operations in the near future, some PLA thinkers expect higher levels of autonomy will be an inevitable feature of the future battlefield.[85] Consequently, 'algorithmic advantage' is expected to become a decisive factor for future victory.[86]

**New Risks and Security Dilemmas**

Are the United States and China engaged in an "AI arms race" at present? It is clear that the U.S. and Chinese militaries share a strong interest and are undertaking increasing investments in the military applications of these technologies. Although attempts to predict and anticipate the future of warfare are imperfect at best, there is consensus that artificial intelligence and autonomy will have a range of impactful applications that could, in the aggregate, constitute a new AI-enabled "Revolution in Military Affairs" ('AI-RMA'), potentially in conjunction with other emerging technologies, ranging from hypersonics to biotechnology and directed energy weapons. If that does indeed prove to be the case, then whichever military first masters these technologies—and the powerful convergences among them—could achieve dominance in a new generation of warfare. In this regard, concerns over an "arms race" in AI cannot be disentangled from the extant dynamics of intense military rivalry among great powers. Although multiple militaries around the world do appear to anticipate that today's advances in AI could prove transformative, perhaps even revolutionary,[87] the inherent uncertainties and challenges in the trajectory of these technologies' development and operationalization should not be discounted amidst the hype. Moreover, the notion of an "arms race" in AI is inadequate and incomplete as a concept at best, in light of the complexity of these technologies and the multiplicity of their applications. However, today's advances in AI technology could exacerbate current security dilemmas among great powers, particularly considering that these technologies often contribute to qualitative enhancements in the capabilities of potential adversaries in ways that are difficult to evaluate through observation alone. The resulting uncertainties about the military balance could contribute to overreaction to and overestimation of competitors' advances, spurring further investments and increasing competitions.

Indeed, rapid advances in AI could disrupt and destabilize the existing global balance of power, though not necessarily for the reasons that have captured the popular imagination.[88] There seems to be less danger that "killer robots" or "superintelligence" could be created as a result of such competition and more reasons for concern that advances in AI could present new risks to strategic stability, in conjunction with parallel technological developments. If military competition continues to intensify, there are reasons for concern that a "new round of arms racing" could indeed emerge.[89] Nonetheless, there are also ways in which the introduction of AI, including to enhance Chinese early warning capabilities and situational awareness, could prove stabilizing, potentially increasing China's confidence in its capability for rapid response to a nuclear attack.[90] However, Chinese defense academics and strategists, including Professor Zhu Qichao of the PLA's National University of Defense Technology (NUDT), have also highlighted the acute risks that the advent of AI in warfare might present, given the greater speed, precision, and potential for errors.[91] Indeed, AI is recognized as a "double-edged

sword" that could introduce new risks to national security, military security, and societal security, as a recent Chinese white paper on AI safety/security highlighted.[92] The PLA's pursuit of AI-enabled capabilities could exacerbate issues of failures in complex systems, adversary attempts to attack or otherwise undermine autonomous systems, or unanticipated interactions between adversarial systems.[93] For instance, the PLA is also likely to look to AI to enhance its offensive and defensive cyber capabilities, including under the aegis of the Strategic Support Force. The trend towards integrating AI with cyber capabilities to achieve an advantage could intensify escalatory dynamics in this contested domain.

Despite fears that advances in AI are "summoning the demon,"[94] the present limitations of AI, rather than its potential power or questions of controllability, could become more problematic in the near term for China and the United States alike. In some cases, errors and issues might arise in more routine applications, even when the algorithm in question is not used directly in a weapons system or to make a life-and-death decision. Even military applications of AI in intelligence and to augment command decision-making could raise risks of mistakes that might contribute to crisis instability or exacerbate the risks of escalation, potentially creating new avenues for misperception or miscalculation in leadership decision-making. At this stage of development, AI remains far from intelligent, tending to make mistakes no human would make. Such errors can be unpredictable or difficult to mitigate. In certain cases, the results can be amusing or nonsensical, as in the case of adversarial examples.[95] In a military context, however, there could be adverse consequences and new operational risks.[96] There will be a higher likelihood of errors or unexpected emergent behavior as the level of complexity increases and if a situation exceeds the expected parameters, such as in the transition from virtual training to real-world environments. Consequently, major militaries should take a proactive approach to evaluating and mitigating the potential risks introduced by advances in military applications of AI. It is and will remain in their interest to do so, since the United States, China, and Russia still share at least a basic commitment to strategic stability and recognize the undesirability of inadvertent escalation.

Going forward, the United States and China must also recognize the new threats resulting from the likely proliferation of AI-enabled capabilities. Thus far, developments have been propelled forward primarily by commercial technologies, and the companies at the forefront of the field have taken a very open approach to releasing their results, including open-sourcing some of the key tools, algorithms, and infrastructure. Given that the barriers to entry have decreased as a result, there may be more opportunities for non-state actors, including criminals and perhaps even terrorist organizations, to explore options to leverage these technologies for malicious purposes.[97] This trend may converge with that of the cheapness and availability of commercial drones, which will only increase with advances in additive manufacturing. Even terrorist organizations, notably ISIS, are starting to employ drones for battlefield reconnaissance and to convey explosives.[98] The successes of Chinese company DJI, which commands the majority of the world's market for commercial drones,[99] has only rendered these capabilities more and more readily accessible.[100] Concurrently, while AI technologies become ever more pervasive in our societies and economies, new threat vectors may arise, from the potential weaponization of self-driving cars to the manipulation of smart devices. While these "AI superpowers" may reap the greatest benefits from advances in these technologies, it is undeniable that many players and potential malicious actors could develop the capability to exploit them. As American and Chinese policymakers turn their attention to questions of AI safety and security, the shared nature of these threats should be an impetus to explore opportunities for cooperation on risk mitigation.

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# China's Rise in Artificial Intelligence: Ingredients and Economic Implications

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After nearly four decades as the "factory of the world," China today is stepping into a new role in the global economy: as a hub for innovative applications of artificial intelligence. According to one recent study by PriceWaterhouseCoopers, of the $15.7 trillion in global wealth AI is expected to generate by 2030, a full $7 trillion[1] will occur in China alone.

Why did China quickly vault into the top tiers of nations in artificial intelligence (AI)? And what implications will this have for the Chinese and the global economy? These are the questions we seek to answer here. That answer will come in three parts: the nature of recent advances in AI, the way these advances mesh with the particular strengths of China's technology ecosystem, and the economic impact of the AI applications.

In the first section, we will argue that recent advances in AI constitute a transition from an age of *discovery* to an age of *implementation*. In the second section, we will show how that transition to AI implementation plays to certain strengths in China's technology ecosystem and also deemphasizes some of that ecosystem's inherent weaknesses. Finally, in the third section, we will propose a set of conceptual building blocks for analyzing the economic implications of artificial intelligence in China, in the United States, and around the globe.

Both artificial intelligence and China are topics far too expansive and multi-faceted for any one piece to cover in their entirety. There are myriad political, social and ethical questions stemming from artificial intelligence in China, but we will leave these for future discussion. We hope only that the following piece provides a framework for understanding the space where China, AI, and economics intersect.

**I. The Nature of Recent Advances: From Discovery to Implementation**

Understanding China's rise in AI begins with a sound understanding of the technology itself, and where its development stands today. Today the flurry of headlines around AI is both heightening public excitement (and fear) around the technology, but also obscuring how the version of AI in use today works.

Traditionally, artificial intelligence has been a field of computer science concerned with building computer systems that can perform tasks usually reserved for humans: perceiving and interpreting the world around us, predicting outcomes clouded by uncertainty, and making complex decisions. Over the years, researchers debated and experimented with different approaches to constructing these AI systems. Should they code our existing knowledge into computers (an approach often called "expert systems")? Or use software to imitate the process by which our own brains learn, and then let the computers learn for themselves (an approach now called "neural networks")?

Debate between these camps raged[2] for decades within academia, and while many new and exciting discoveries were made by researchers on both sides, the real-world impact of these discoveries remained limited. Throughout the 1980s and 1990s, top international researchers were able to create AI programs that performed certain highly specific tasks: synthesizing robotic-sounding speech, reading the numbers written on a check, or even playing chess better than a grandmaster. But these AI systems often weren't generalizable enough to be of much use to companies. During this era, the center of gravity in AI remained in the laboratory, and the field remained in an age of discovery.

That all began to shift around a decade ago. Early applications of neural networks had often run up against two problems: a shortage of data[3] on which to learn from or limitations in the complexity of the patterns they could spot. Driving that shift were two major changes: an explosion in digital data generated by the internet and the creation of an innovative approach to neural networks known as "deep learning." The explosion in digital data from the internet captured many human activities (reading, watching videos, socializing, etc.) in a format that computers could process. The creation of deep learning gave AI systems a better way to learn from that data, empowering them to spot subtle correlations between different data points.

Deep learning's ability to pick out incredibly subtle patterns within oceans of data is what powers AI applications today. Neural networks powered by deep

learning are fed streams of digital data (credit card purchases, pictures of faces, driving records) and then use their superhuman pattern spotting abilities to predict the best answers to important questions (Is that purchase fraudulent? Whose face is that? Swerve right or brake?).

While a human brain tends to focus on the most obvious correlations between the input data and the outcomes, a deep learning algorithm trained on enough data will discover connections between obscure features of the data that are so subtle or complex we humans cannot even describe them logically. No single one of those connections or features can correctly predict an outcome, but when you combine hundreds or even thousands of them together, they can outstrip the performance of even the most experienced humans.

Concretely, these superhuman abilities of pattern analysis have given computers two new powers: the power of perception and the power of complex (non-linear) decision-making. For perception, where "dumb" digital devices could merely capture and reproduce images or sounds, "smart" AI programs can now identify and understand the content within those images and sounds. For complex decision-making, AI programs are no longer limited to binary "if-then" rules coded by a human, but can instead learn a far more flexible set of rules based on what they find in the data. Combining these powers with software (computer programs) and hardware (robotics) allows AI to take over countless tasks across society: driving a car, diagnosing a disease, assembling a sneaker, or making a mortgage loan.

With deep learning and the data explosion as catalysts, AI has moved from the age of discovery to the age of implementation. Research into frontier areas of AI continues at a furious pace, and discoveries in these areas may yet unlock vast new possibilities. But for now, at least, the center of gravity has shifted from elite research laboratories to real world applications. In essence, deep learning and data have boosted AI up onto a new plateau. Companies and governments are now exploring that plateau, looking for ways to apply present AI capabilities to their activities, to squeeze every last drop of productivity out of this groundbreaking technology.

Google CEO Sundar Pichai has compared the power of AI to humankind's harnessing of fire.[4] Analogies on that scale are inherently speculative and necessarily imprecise, but they can also be illustrative. If AI is fire, then the age of discovery is the period in which humans slowly, steadily learned the methods for generating a spark and capturing it in the form of a flame. The age of implementation is the era in which humans learned to apply that flame to all the tasks in their life: cooking food, staying warm, fighting wars, burning underbrush to open up land, and creating elaborate paintings within the darkness of a cave. These implementations of fire are analogous to the rapid exploration and commercialization of AI today: the self-driving cars rolling out on our streets, the AI-powered research into cancer treatments, the cashier-less Amazon Go stores, and the autonomous robots scurrying about our warehouses.

**II. The Ingredients of AI Implementation: Research Talent, Data, Company Ecosystem, and Government Policy**

The transition from discovery to implementation also has momentous implications for the drivers of AI progress, and thus which countries are likely to lead the world in AI applications. AI today can be thought of as containing four key ingredients: research talent, data, a company ecosystem, and government policy. (Semiconductors are also a key AI ingredient, though due to the technical complexity and high level of uncertainty regarding their development trajectory, we will set them aside for the purposes of this analysis.) The transition from an age of discovery to an age of implementation is reordering the relative importance of each of these ingredients and also alters what *kind* of talent, data, or corporate ecosystem is most likely to drive progress.

In the paragraphs below, we will examine China's strengths and weaknesses in each of these four ingredients—research talent, data, company ecosystem, and government policy—and from that analysis propose an answer to our first question: why did China quickly vault to the top rank of nations in artificial intelligence? We will show that while China is by no means guaranteed leadership in all fields of AI, the transition from discovery to implementation will on balance highlight some of China's comparative strengths, and deemphasize some of its weaknesses.

*Research Talent*

In an age of discovery, a nation's AI prowess is determined primarily by the quality of a small group of elite researchers: the best-of-the-best academic talent who can push the boundaries of knowledge outward. But as the center of gravity in AI moves from research in the lab (discovery) to the building of commercial applications (implementation), it brings with it an analogous transition away from prizing the *quality* of elite researchers and toward prizing the *quantity* of competent engineers: the number of people who can take the research breakthroughs and apply them across hundreds of different industries.

The United States undoubtedly holds an advantage in the quality of its top-notch researchers. Our subjective analysis of the field concludes that virtually all of the top ten, and a large majority of the top one-hundred, AI researchers around the globe are located in the United States or Canada, and are affiliated with U.S. institutions. This is why many U.S. institutions led the way in the age of discovery, and why they entered the age of implementation with a substantial lead over their international peers.

But as activity shifts to commercial applications, that leadership is no longer guaranteed. Chinese researchers have yet to produce research breakthroughs on the scale of deep learning, but they make up an increasingly large share of productive AI researchers and engineers.

A study conducted by Sinovation Ventures found that between 2006 and 2015 publications in the top one hundred AI journals and conferences by authors with Chinese names nearly doubled from 23.2 percent to 42.8 percent.[5] These percentages include some international researchers with Chinese names—Chinese Americans who haven't adopted an anglicized name, for example—but a scan of the researchers' institutions validates that a large majority of them are working in China today.

That study only charted progress through 2015, a year before AlphaGo's historic Go match against Lee Sedol and then Chinese world champion Ke Jie. Those matches have been likened to China's "Sputnik moment"[6] on AI, a turning point that helped set China on the path to becoming an AI superpower by firing the public imagination and inspiring young scientists to redouble their efforts. That public excitement has nudged thousands more Chinese computer science graduate students into pursuing artificial intelligence research.

This is the pool of talent that an age of implementation thrives on: the computer science Ph.D.'s who aren't in line for a Nobel Prize, but who could easily transition into being the Chief Technology Officer of an AI startup or a product lead at a large company like Google or Baidu. As these implementers fan out across the country's AI ecosystem, they will bring the power of AI to bear on hundreds of new problems, generating value for their employers and driving economic growth for China as a whole.

It's worth noting that there are potential events that could bring this current era of deep-learning-driven implementation to an end. If researchers were to make another breakthrough on the scale of deep learning—a new approach that dramatically increases the power of algorithms to understand and learn—then it could precipitate a temporary return to an age of discovery. The center of gravity would once again return to research labs, and the United States' advantage in best-of-the-best research could once again grant it a major advantage in AI development. How long that advantage held would depend on whether the discovery were to come out of academia (and thus be openly published) or occur within the confines of a company like Google, where trade secrets could keep the knowledge bottled up for longer before it disseminated to the international research community.

But for now, at least, the current age of implementation appears well-suited to China's strengths in research: large quantities of highly-skilled, though not necessarily best-of-best, AI researchers and practitioners.

*Data*

The transition to the age of implementation has also dramatically increased the value of the second AI ingredient: data. Data can be viewed as the raw material on which AI runs, analogous to oil's role in powering an industrial economy. As an AI algorithm is fed more training data—past examples of the phenomenon you want the algorithm to understand—it gains greater and greater accuracy. The more faces you show a facial recognition algorithm, the fewer mistakes it will make in recognizing your face; the more medical records you show to a diagnostic algorithm, the more accurate its predictions will be on whether a new patient has cancer. Generally speaking, an algorithm designed by competent (but not outstanding) researchers that is fed large volumes of training data will outperform an algorithm crafted by the world's best AI scientists, but trained on less data.[7]

This link between data and real-world performance has been true for decades, but in the age of discovery it did not matter nearly as much. The inability to commercialize the current state of the art meant that the field focused on academic publications, which often require novel approaches to algorithm design in order to pass peer review. Simply achieving better performance on an existing algorithm by supplying it with greater data is not enough to get an academic paper published.

But it is enough to generate a superior product in the marketplace. With those commercial products now made possible by deep learning, data has become one of the most precious resources of an AI company. Relatively speaking, this tilts the playing field away from those companies with the most elite research talent, and towards those companies with the largest stockpiles of user data.

At first glance, it's not immediately clear whether this shift to data-driven AI implementation would aide companies from China or the United States. Companies from both countries have different strengths when it comes to data, strengths that can be understood better if we map the monolithic concept of "data" across three dimensions: breadth, quality, and depth.

Breadth refers to the number of users of a given service, the population whose actions are captured in data. Quality refers to how well-structured and well-labeled the data is. Using medical diagnostic data as an example: is that data already formatted into uniform Excel documents easily readable by an AI algorithm, or stored on slips of paper across thousands of different filing systems? And was the human-made diagnosis that the algorithm is learning from correct in the first place? Finally, depth refers to how many different data points are generated

about the activities of *each user*. In essence, how many different activities of a given user are captured in digital form that AI algorithms can learn from, allowing them to better predict a user's needs.

On the first dimension, breadth, Chinese and American companies are on relatively even footing. While American internet companies have a smaller domestic user base than their Chinese peers, the most successful among them can also draw in users from around the globe, bringing their total user base to over a billion. Chinese companies have a much larger domestic population to draw on (1.1 billion[8] mobile internet devices on 4G), and are now starting to make inroads with international users from Southeast Asia to South America.

On quality of data, American organizations enjoy a distinct advantage: companies and public institutions in the United States are much more likely to use enterprise software that structures their data for immediate use. Chinese corporations and public entities are moving in this direction, in part due to increased bureaucratic incentives for utilizing data. Still, they lag substantially behind U.S. organizations in terms of accumulation of AI-ready data.

But on depth of data, China has the upper hand. Compared with their American peers, Chinese internet users funnel a much larger portion of their daily activities, transactions, and interactions through their smartphones. They use their smartphones to buy vegetables at the market, manage their social security, pay their water bills, book bus tickets, take out loans, and so much more.

Some of this is due to a leapfrog effect. While the slow-and-steady development trajectory of the United States has led to an accumulation of legacy systems, China's high-speed development skipped many steps. Chinese consumers never embraced credit cards, and so they jumped straight from an all-cash economy to using their smartphones for mobile payments at real-world outlets. Similar leaps have led to more rapid adoption of digital sharing economy services, with Chinese users accounted for a full 68 percent[9] of rides on shared bikes and ride-hailing services.

Weaving together these different strands of data—mobile payments, public services, financial management, shared mobility—gives Chinese technology companies a deep and multi-dimensional picture of their users, one that allows their AI algorithms to precisely tailor product offerings to each individual. This will prove highly valuable in the manifold consumer applications of AI: offering mortgage loans, optimizing supply chains, and operating automated supermarkets and convenience stores that can predict what, when and where each product is needed. In the current age of AI implementation, this will likely lead to a substantial acceleration and deepening of AI's impact across the Chinese economy.

*Company Ecosystem*

The corporate technology ecosystems of the United States and China are united by several characteristics: unmatched size, parallel funding structures, analogous product verticals, and high innovative capacity. But when it comes to the cultural norms that animate these ecosystems, they diverge in substantial ways that will impact the speed and the nature of AI adoption. Most notable among these cultural differences is the attitude toward imitating, iterating, and rapidly scaling successful business models pioneered by others.

For illustrating this divide, it's useful to introduce an analytical framework popularized by Peter Thiel: the difference between "0 to 1" and "1 to n" innovation. Zero to 1 innovation[10] describes the process of creating original and radically new products or services. By contrast, 1 to n innovation involves scaling up and iteratively improving an existing offering. This clean dichotomy is inherently reductionist: no new products truly begin from "0," and moving from "1 to n" is not the linear process implied by the title. But they do offer conceptual frames that are useful for understanding the unique cultural undercurrents of China and Silicon Valley.

Silicon Valley (and the U.S. tech ecosystem more broadly) both prides itself on and excels at 0 to 1. In U.S. tech circles, there is great prestige attached to outside-the-box thinking, and significant levels of stigma for those who merely imitate existing models. As a result, the U.S. ecosystem carries a more significant first-mover advantage, allowing the pioneers of a model to patiently harvest the low-hanging fruit borne out of their original idea.

China's technology ecosystem, by contrast, tends to excel at the 1 to n part of the innovation equation. Chinese tech entrepreneurs are far more cautious when it comes to experimenting with radically new ideas, but they have no hesitation when it comes to imitating and improving on a successful business model. The reasons for this are complex, including everything from millennia-old cultural traditions, to the breakneck pace of economic development in recent decades. But the results are clear: when a new technology or business model is proven to work, dozens or even hundreds of Chinese startups flood into that industry and compete ferociously for dominance.

What happens next can best be compared to evolutionary natural selection. Hundreds of organisms (startups) of the same species (business model) scratch and claw for scarce resources (users and venture capital funding), differentiating themselves through subtle genetic mutations (tweaks to models or increased operational efficiency). The vast majority of these organisms perish, while those with mutations that bring in more users and capital survive to fight another day.

At a corporate level, this process doesn't necessarily reward the most original companies but rather those that are the best at iterating and executing. At a systemic level, this process is extremely effective at exploring and exploiting hundreds of different applications of a new technology or business model. With none of Silicon Valley's deference for first-movers, the pace of 1 to n innovation is accelerated, and many more branches of the genetic tree are explored.

In the past decade, we've witnessed this process play out time and again in China with the advent of the mobile internet, sharing economy, online-to-offline commerce, live streaming, and many more sectors. In each of these sectors, it's proven to be a process optimized for fast execution, risk taking, and incredibly thorough exploitation of profitable applications.

At the same time, that process can be ugly and, looked at in a narrow sense, wasteful. It produces many copycats and fewer radically new innovations. Hundreds of millions of labor hours and venture capital dollars are spent on nearly identical companies, the majority of which won't survive. But when the potential upside of a new industry or technology is large enough, the results can be just as awe-inspiring as the introduction of a radically new 0 to 1 idea.

What does this all have to do with AI? The 0 to 1 innovation that Silicon Valley excels at meshed well with the age of AI discovery, while China's focus on 1 to n is ideal for exploiting all the manifold possibilities of the age of AI implementation. With the discovery of deep learning behind us, the most immediate economic question becomes how will AI's powers of optimization-via-data be applied to different tasks and industries. By cultural inclination and ecosystem dynamics, China appears primed to mine this technology for all it's worth.

As noted above, these categories—"0 to 1," "1 to n," "original," "copycat"—are inherently reductive and in no way capture the full complexity of either ecosystem. Many American startups have few qualms about imitation and display similar competitive instincts to their Chinese peers. The 2018 rush into scooter-sharing startups has echoes of the Chinese competitive model, and was in fact inspired by Chinese success in bike-sharing. Similarly, some Chinese companies have demonstrated remarkable creativity and originality in their products and business models. Tencent's WeChat long ago transformed from a simple chat app to a globally unique super-app,[11] and Alibaba's City Brain project has the potential to introduce a radically original vision of AI-powered urban infrastructure management.

But as a broad framework for mapping the strengths and weaknesses of these two ecosystems onto the current phase of AI development, we believe this dichotomy holds valuable explanatory and predictive power. While the Chinese technology ecosystem has many weaknesses, its strengths are particularly suited to maximizing the economic potential unleashed during the age of AI implementation.

*Government Policy*

The role of government policy in driving China's progress in AI is both widely remarked upon and widely misunderstood. Those misunderstandings often fall into two differing conceptions of the primary mechanism by which the Chinese government drives AI development: picking winners that it showers with subsidies, or by issuing top-down commands dictating what technologies to create.

There are, of course, ways in which the government subsidizes certain AI companies and also instances in which China's science and technology bureaucracy mobilizes to develop certain technologies. On subsidies, the government actively incentivizes private venture capital (VC) investment in AI through "guiding funds,"[12] a clever financial structure by which the public funds are used guide funds into certain sectors by increasing the upside for private VC investors without removing the risk for them. In terms of top-down directives, China's Ministry of Science and Technology has set ambitious and highly specific targets for the performance of indigenously produced AI chips, and it is pouring major resources into achieving those goals.

These efforts are real, and they both stimulate and, in some cases, distort China's private sector AI development. But as the age of AI implementation bears its most substantial fruit, subsidies and top-down commands will likely not be the government's most impactful means of accelerating AI development. Instead, it will be the way that the central government's AI development plan incentivizes local officials to work with private sector actors on *adapting public infrastructure* and *accelerating public adoption* of AI. Unpacking that mechanism requires drilling down further on the coming waves of AI implementation.

Our current phase of AI implementation has been deeply impacting certain industries for close to five years. The reason why this impact isn't always obvious to the casual observer is that it has thus far been largely confined to data-driven companies in sectors such as the internet, finance, or insurance. Deep learning first made landfall in these sectors because the implementation can be handled entirely by the private sector: Alibaba needs no government cooperation to deploy AI in optimizing its ad choices, and Goldman Sachs doesn't need to engage the White House to leverage big data analytics for its investment decisions.

But if AI is to expand its impact from the data-driven digital world into the physical world—via autonomous

vehicles, medical AI, smart cities, etc.—it will likely require the proactive adaptation of public infrastructure, and proactive adoption by public entities. Accelerating deployment of autonomous vehicles may entail slight changes to public roads, such as embedding sensors or reserving separate lanes for pilot programs. Bringing AI's benefits to the public education or healthcare spheres will require analogous tweaks to those systems. All of these changes will necessitate the creation of new regulatory frameworks, laws that can embody shared values of privacy or responsibility while harnessing the new possibilities unlocked by the technology. Each of these moves—adapting public infrastructure, adopting new technology tools, and piloting new forms of public-private cooperation—requires a certain degree of political risk, particularly in highly combative political systems.

This is where China's "New Generation Artificial Intelligence Development Plan" will have some of its deepest impacts. Rather than representing a top-down blueprint for AI development, the plan functions above all as a *signal*, one that is broadcast to local officials throughout China's sprawling bureaucracy. It imbues AI with a stamp of approval from the central government and the Chinese Communist Party, both de-risking and actively incentivizing local projects that make use of AI in some way.

The career trajectories of these officials are largely determined based on performance assessments, and an initiative as high-profile as the AI development plan can make AI promotion another metric on which these officials will be evaluated. If the AI projects these local officials push bear fruit, they will be rewarded. If those projects fail, the bureaucratic costs of that failure will be substantially lower given that they occurred within the framework of an officially sanctioned push for AI.

Which manifestations of AI these officials choose to adopt will largely depend on their role in the bureaucracy, as well as local economic structures. An agricultural official in southwestern China might look to push a pilot project using autonomous seeding drones at state-owned agricultural facilities. A mayor in a packed city might work with Alibaba to install the infrastructure for a City Brain project that optimizes traffic and emergency services using computer vision. A university president in a manufacturing region might establish a new public-private research institute focused on factory automation. Across the board, these local bureaucratic actors will employ a range of tools: public procurement, pilot projects, infrastructure adaptations, subsidies, and regulatory accommodation.

This combination of central government signaling and local government implementation is particularly suited to accelerating implementation of an "omni-use technology" like AI, one that can be directly applied to thousands of different tasks. No command-and-control structure or single blueprint could efficiently direct state resources toward exploiting all the manifold applications of AI. Likewise, throwing subsidies at every AI company across the economy would be wildly inefficient and ultimately unfeasible. But if this model of the AI plan plays out as intended, it could represent a powerful synergy of central direction and local flexibility.

This model of central signaling and local application could have other potential downsides as well. If AI ended up falling far short of current expectations of its economic impact, then directing this level of bureaucratic and financial resources toward maximizing its value could prove wasteful. But if the above arguments on the transition to the age of implementation hold—that is, no new breakthroughs are required to generate large economic returns from application—then we believe this outcome is unlikely. Many of the economic fruits of AI are already ripe, and it is largely a question of which ones require public sector adaptation or adoption to be picked. Substantial government involvement is by no means a prerequisite for technological leadership, but as AI seeps deeper into the real-world systems that surround us, that adaptation and adoption will likely accelerate the economic impact of the technology.

**III. Economic Implications**

The above sections have outlined our answer to the question of why China has so rapidly vaulted into the top tiers of AI powers worldwide. The following section will examine the economic impact of AI technology in China and elsewhere, with a focus on employment, inequality, and potential policy responses.

There is major debate within economics and policy circles over the pace and scope of jobs at risk of being replaced by AI-powered technology. Low-end estimates have pegged that number at just 9 percent,[13] while other studies have placed it at 47 percent[14] by the early 2030s. The reasons for that wide range of outcomes, and precise predictions of the percentage of jobs put at risk by AI, are beyond the scope of this paper. (For a detailed analysis and critique of these studies, see chapter six of *AI Superpowers: China, Silicon Valley, and the New World Order*.[15])

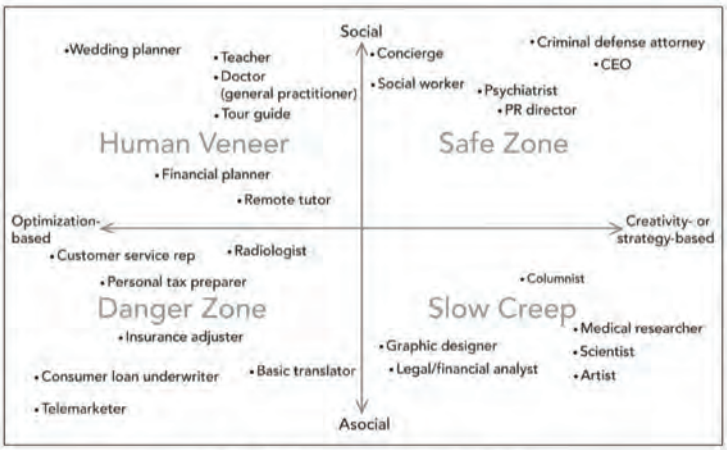
Instead, we will draw on the nature of the technology itself as a source for constructing key conceptual building blocks that can lay a foundation for further discussion. Specifically, we will look at what the functioning of AI can reveal about the *kinds* of jobs that are at risk, the impact on competition between firms, and how this maps onto the broader macroeconomic and geopolitical landscape.

*Jobs*

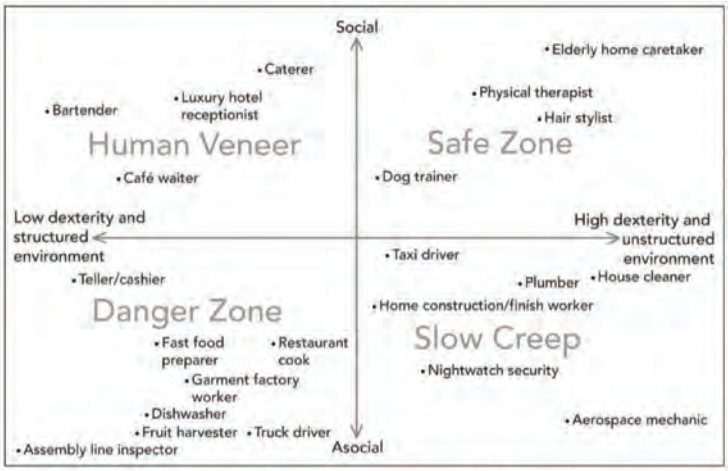
We have already described in general terms the key mechanisms behind deep learning-driven AI systems: using large quantities of training data to discover subtle correlations between inputs and outcomes, correlations that help the system make predictions of future outcomes with superhuman accuracy. While this mechanism can be incredibly powerful under certain conditions (abundant data, narrow goals, and clearly labeled outcomes), it also has limitations.

Specifically, AI today cannot perform well when there is insufficient digital training data on an activity, or when outcomes cannot be clearly quantified or categorized. For cognitive tasks, this means AI struggles at highly strategic or creative tasks with unclear goals, or highly social tasks that require a nuanced understanding of another person's emotions. For physical tasks, AI-powered robots operate well in highly structured environments (factories, highways) but struggle with unstructured environments (messy homes) or tasks that involve high dexterity and a gentle touch.

Mapping these abilities and limitations in two-dimensions yields the following Risk-of-Replacement Charts for both cognitive and physical labor:




*Risk-of-Replacement: Cognitive Labor*




*Risk-of-Replacement: Physical Labor*

Each chart is broken down into four quadrants that will see different impacts from AI. In the bottom-left "Danger Zone" – jobs that are a-social and repetitive – humans have little advantage over AI, and we expect these jobs to be replaced on a long enough time horizon. In the "Human Veneer" quadrant of the upper left — repetitive and social — many of the core tasks may be taken over by AI, but there remains a social component that people will continue to perform. This quadrant may see reductions in total jobs, with a smaller number of workers providing that human interface.

The "Slow Creep" section is comprised of a-social jobs that remain beyond AI's current narrow limits of strategy or dexterity. These are safe for the time being but are vulnerable to getting vacuumed up as AI expands its ability to multi-task. Finally, in the "Safe Zone" of the upper right-hand quadrant are jobs that remain well beyond AI's current capabilities in terms of creativity, strategy, dexterity and sociability.

Clearly, this two-dimensional categorization of jobs is inherently reductionist, smoothing over great diversity of tasks within each profession, as well as the social and political structures that will protect certain occupations but not others. These are all very important factors that will affect the pace and scope of jobs lost to AI and are deserving of further examination. The above charts are merely offered as a conceptual framework for how AI's technical capabilities map onto current professions and a starting point for a conversation on employment impact on AI.

Broadly speaking, they can also suggest the directions of a long-term workforce transition, one that could prove as momentous as the 19th and 20th century transitions from agriculture to manufacturing. In the context of these graphs, any skill transitions that move a worker up (more social) or to the right (more creative, strategic, or physically dexterous) are likely to increase their job security. Taken out to a macro level, this would indicate an economy-wide shift toward more care, service, and creative jobs. These would include not just high-education professions such as attorneys or therapists, but also nurses, coaches, and those who care for infants or the elderly.

*Job Impacts in China and the United States*

As noted above, predicting the precise scale of jobs put at risk by AI is beyond the scope of this paper. Instead, we will offer up some conceptual building blocks for how the nature AI implementation and the distribution of occupations in the two countries will affect the pace and size of job losses.

Conventional wisdom holds that Chinese workers will be hit far harder by AI replacement, with China serving as "ground zero for the economic and social disruption brought on by the rise of the robots." The argument here

is straightforward. Nearly one half of Chinese workers are on farms or factories. They often perform highly repetitive tasks, and one main reason these factories are located in China is because of the country's cheaper wages and large population. Once intelligent robots can perform those same tasks (for zero pay and operating 24 hours per day), the factories will leave China, saddling it with massive layoffs in the industrial sector. This story has an internal logic, and it matches with our what we've observed in the United States this half century about what kinds of jobs get lost to automation: factory and farm jobs. We've also seen instances of this process at work already, with reports of Chinese electronics mega-factories replacing[16] tens of thousands of workers with robots.

But this process may not be as speedy or disruptive as some predict. The reason behind that is often called Moravec's Paradox: contrary to popular assumption, it's easy for AI to mimic high-level intellectual or computation abilities, but far harder to give a robot the sensorimotor skills of a toddler. Some of this has changed since the Paradox was first articulated in the 1980s; robots have gotten far better about sensing the world around them but continue to have difficulty in manipulating objects with the dexterity of a human hand.

The result is that pure software applications of AI are far easier to create, free to instantly disseminate around the globe, and can be tweaked remotely with each new update. Robotics is a trickier business, requiring a complex interplay of mechanical and electrical engineering, perception AI, and fine-motor skill manipulation of objects. The products must then be constructed, shipped around the world, and often fixed by trained technicians on-site.

This has major implications for the *sequence* of AI induced job losses. While it may seem that China's legions of factory workers are in immediate danger of unemployment, the many frictions of deploying functioning robotics across an economy may substantially slow that process down, giving the workers (or their children) time to integrate into more social or non-repetitive jobs.

U.S. workers have their own sets of protections. Aside from protections for unionized employees, American workers also cluster more in service industries, from education to sales to public relations. Needed social skills such as persuasion or empathy will help to insulate them against immediate pressures from AI. At the same time, America's own legions of middle-class, college-educated office workers, those whose jobs it is to take in data and make predictions about outcomes, face shakier prospects. Without a substantial social or strategic component to their work, workers in these occupations are at risk of being replaced by algorithms that are created easily, distributed freely, and updated remotely. Reports in June of 2018 that Citigroup executives were discussing replacing up to 10,000[17] of the company's 20,000 operations and technology employees with machine learning in the next five years are testament to just how sweeping these changes could end up being.

Scanning the economic landscape of these two countries, it's not clear which will experience deeper employment impacts from AI on a ten- to fifteen-year time scale. Both countries have large swaths of jobs that would be *technically feasible* to automate in the near future but also social and logistical buffers against that automation taking place immediately. The clearer divide emerges when we compare economic impacts not between the United States and China, but when we look at the technology's impacts on inequality on the individual, firm, and international levels.

*The AI Inequality Machine*

One notable characteristic of the above Risk-of-Replacement charts is the mix of jobs located in the upper-right "safe" quadrants: the occupations listed here tend to fall on the very high- or relatively low-earning end of the spectrum, with CEOs, home care workers, trial attorneys, and hair stylists all performing tasks that are outside of AI's reach. While all of these jobs may appear "safe" for the time being, the rewards granted to each will be dramatically different: many CEOs will leverage AI against their existing capital and data resources to generate astronomical returns, while home care workers unable to leverage AI for their work will likely find themselves squeezed by competition from an ever-larger pool of similarly-skilled workers.

This points to another conceptual building block for understanding this economic impact: AI as a technology is inherently monopolistic, exerting a gravitational pull that concentrates profits in the hands of a few. This is what we call the "AI inequality machine," and it occurs on multiple levels: individual jobs, firms, and countries. Driving this monopolization are self-reinforcing cycles of data accumulation, improved performance, and greater personalization for users. Data is one of the key ingredients in building effective AI, and it tends to enter one of these self-reinforcing cycles of accumulation: the more data you have, the better your AI product performs, the more users you draw in, the more data you have.

AI's capacity for learning and thus tailoring its actions to each individual user also helps it escape a normal trade-off between scale and personalization in a product. For AI, the data offered by scale can actually mean greater personalization: algorithms trained on more data will actually be better trained to offer you exactly the product or experience that suits your own needs. The customer may experience this as the product simply "working better," but it has major ramifications for firm-level competition across the economy. If left unchecked,

it could further winnow down the number of competitive firms, establishing an oligopolistic system dominated by just a handful of companies.

On an international level, these dynamics are already taking hold. Today just a handful of companies have emerged as the AI giants, with virtually all of them based in the United States and China. This reflects existing concentrations in user data and engineering talent and major investments in AI that have given these giants a massive head start. If that growth goes unchecked, it's possible that these firms leverage their existing advantage to branch out and dominate traditionally offline industries around the world: autonomous transportation, "dark factories" with no workers, cashier-less grocery stores and AI-driven medical care. If they did so, we would see improvements in products used by consumers but ever-greater concentration of profits in the hands of just a few companies in an even smaller number of countries.

Developing countries will face their own AI challenges. As automation of physical and cognitive tasks deepens across the global economy, it will pull away the bottom rungs of the ladder of economic development. Traditional development models in countries like China and India have relied on comparative advantages in low-wage manufacturing or English-language call centers to kickstart the development process. Moravec's Paradox ensures these factory jobs aren't disappearing overnight, but it's unlikely we will see multinational corporations build extensive new supply chains in low-wage countries before putting that investment into automation. With these traditional development models closed off by intelligent machines, these countries will need to find new ways to claw themselves out of poverty in a world where both wealth and economic production are increasingly concentrated within an elite group of individuals, firms, and countries.

There exist several possible ways in which the global AI economy could change course. Perhaps European or American regulators will break up existing tech monopolies. Or maybe countries such as India will combine a large population, engineering talent, and localization advantages to build up AI giants that serve their domestic markets. Or, in a move that would lead to even greater consolidation, maybe a technique to supplant deep learning is invented and kept in-house at a place like Google, giving just one company an incalculable advantage over all others. At this point, we can't predict which of these contingencies will come into play.

**IV. Conclusion**

The above article has attempted to construct key conceptual building blocks derived from the capabilities of AI technology itself. Those building blocks have included (1) AI's transition from an age of discovery to an age of implementation; (2) the role of key ingredients such as research talent, data, company ecosystems, and government policy; (3) the powers and limitations of present-day AI, and how these interact with the employment landscape; (4) the role of Moravec's Paradox in the *sequence* of employment impacts; and (5) the way AI's tendency toward monopoly will affect individuals, firms, and countries.

Piecing together these building blocks, we sketched out several potential economic impacts deriving from the technology. These are by no means set in stone but are rather offered as starting points for discussions of how AI will impact economies both local and global. Our hope is that this discussion provides a solid foundation for exploring future trajectories of AI's social and economic impacts. The AI revolution must not become another wedge driving inequality, but rather should be used to take better care of the most vulnerable, while sharing benefits broadly across society. We invite, and look forward to engaging with, further studies from a range of disciplines addressing AI's impact on employment, inequality, and our shared communal bonds.

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# How Chinese Authorities and Individuals Use the Internet

**By Maria Repnikova,** Georgia State University

The adoption of the Internet by the Chinese government in the 1990s was part of China's ambitious economic reform and opening up. Introducing information and communication technology was seen as a pathway toward innovation, attraction of foreign direct investment, and global competitiveness. In the past two decades, China has significantly reaped the benefits of the Internet. It is now at the forefront of digital revolution. China is moving quickly toward a cashless economy and leads the world in digital commerce, accounting for 40 percent of global e-commerce transactions.[1] The number of China's Internet users has surpassed 730 million, with more than half of the Chinese population now active online. From commerce, to governance, to journalism, to routine communication, much of Chinese life is increasingly virtual.

While Internet expansion is integral to China's economic project, it also poses new challenges for the Chinese Communist Party. To the disappointment of many Western analysts, social media did not translate into democratization in China, but it did create an unprecedented space for public expression. Since the early 2000s, China has been marred by "public opinion incidents"—Internet-driven, contentious events that capture national public attention. They include public allegations against official corruption, expressions of discontent about polluting factories and social inequality, and many other thorny issues. Discussions begin online, travel into mainstream media, and at times transform into actual protests, awakening authorities to the powerful role that the Internet can play in transmitting public discontent. At the same time, the traditional media that used to be the key weapon of the party in guiding public opinion are atrophying. Mirroring the journalism crisis in the West, in the last three years alone, China's print media have lost three-quarters of their advertising revenue to competition from big-data news aggregators and individual social media platforms.[2] This financial loss accompanied declining public trust in mainstream media, signaling the weakening of China's propaganda apparatus.[3]

The Chinese state now faces at once a more vocal and a more diverse public opinion, less amenable to traditional propaganda. In response, Chinese authorities at the highest levels called for recapturing the Internet. At the very start of his leadership, Xi Jinping named the "battle" for public opinion one of the core objectives of the party.[4] In recent years, Chinese authorities have implemented a number of upgrades in their use of the Internet. These include new strategies in e-governance and online persuasion, as well as innovations in control of Internet use, including new forms of censorship and surveillance. Understanding these strategies is important not only for our engagement with China but also for thinking about global Internet policy as China emerges as a potential model for other, illiberal, countries to follow when it comes to Internet governance.

## The Chinese State Online: From Co-Optation to Containment

### *Chinese Internet as a Tool for Governance*

Chinese authorities use the Internet to modernize governance, sharpen persuasion, and control public opinion. While censorship tends to dominate much of Western reporting, the Chinese government also deploys the Internet for some democratic functions, such as soliciting public feedback and responding to public concerns. In addition to polling and town hall meetings, Chinese officials are now encouraged to actively study, solicit, and engage with public opinion online in an act some refer to as "authoritarian deliberation."[5]

Much of this online public deliberation takes place on official microblogs or official Weibo (the Chinese version of Twitter). The number of Chinese official Weibo accounts now exceeds three hundred thousand and the number of government WeChat accounts amounts to over seventeen thousand.[6] These microblogs serve multiple functions, including news conferences, online polling, and other feedback channels. Citizens are invited to share concerns on a wide range of issues, from forced demolitions to unpleasant local dining experiences.

The accounts are run by diverse official units, including central-level state and party bureaus, courts, public security agencies, propaganda offices, and local officials. The public security sector dominates in official

Weibo accounts.[7] This isn't surprising, considering stability maintenance is at the heart of China's legitimacy battle. Most feedback gathering happens at the local level, as local issues are less sensitive. In addition to official microblogs, Chinese mayors, for instance, have set up the so-called "mayors' mailboxes," platforms specifically designed for residents to share complaints and concerns with city officials. These mailboxes are popular with citizens for launching sharp complaints, especially in the area of environmental protection.[8] The public itself can appraise official digital responsiveness via surveys administered by China's official media outlets. *People's Daily*, for instance, has a weekly online program that ranks the effectiveness of official Weibo in solving problems, selecting the "timeliest" and the "warmest" reply of the week.

Other than corresponding with the public via individual official accounts, Chinese authorities closely study popular discussions on China's major social media platforms—like Weibo, Tianya, and WeChat—to spot sensitive topics, potential societal conflicts, and issues in need of urgent addressing. Many officials are specifically hired for the function of online public opinion monitoring to report worrisome trends to their colleagues and superiors, who can then try to preempt crises or avert public opinion incidents. According to some analysts, the number of public opinion analysts now exceeds two million and there are over 800 businesses specifically dedicated to helping governments monitor public discussions online.[9]

Similar to democratic systems, the effectiveness of China's e-governance efforts is mixed, featuring selective responsiveness, with many issues (especially at the central level) left unaddressed. Considering the controlled nature of the Chinese Internet, the extent to which public deliberation is truly encouraged remains questionable. The more sensitive comments are quickly deleted, preempting wider public mobilization around these issues. However, the projection of official responsiveness or the "consultative" nature of Chinese governance is in itself significant as a legitimacy-boosting attempt by the Chinese state.

*Chinese State Revamping Digital Persuasion*

Responsiveness and creation of deliberative spaces online is accompanied by intensified official efforts at digital persuasion. The Chinese government is working on revitalizing official social media channels and their messaging techniques. In addition to expanding official microblogs, Chinese authorities have propelled media convergence or integration of traditional media with online platforms. This includes investing in brand new digital news outlets and online remaking of traditional party mouthpieces. The Chinese state invested millions into new media journalistic initiatives at the local level, with Shanghai alone pouring 560 million yuan into the digital propaganda sector. Unlike Western journalism, heavily constrained by limited funding, Chinese journalism is supported by the state with immense investments aimed at creating slick, credible, state-owned outlets that would fulfill the propaganda mission online. Some of these efforts are paying off, with fresh news outlets, like Shanghai-based *Pengpai*, gaining popularity among urban middle-class readers. In addition, the authorities hired teams of young people to operate official social media accounts to make them more attractive to youth by publishing human interest stories, entertaining videos, and even romantic discussions that would typically appear on blogs or in commercialized newspapers. To the surprise of many observers, in contrast to their print counterparts, these social media accounts have become highly influential with the public. The social media accounts of official mouthpieces like *People's Daily* and CCTV ranked as number one and number two, respectively, in 2016, outcompeting many of their commercial counterparts.[10]

The propaganda practices of Chinese authorities are also becoming more nuanced in the digital age. Unlike the stiff, official language of print newspapers, social media channels fuse political reports with entertainment and timely service announcements. In channeling official information to the public, for instance, official online accounts invite users to read through all major speeches by President Xi, track his international and domestic visits on a digital map, and even post questions to political delegates at the National Party Congress. Xi himself is portrayed as more personable and engaging than previous top leaders. Images of him traveling overseas, greeting common people, and solving problems flood the Internet.

The official platforms also lure users via service provisions by publicizing timely advice columns on relevant topics, such as tips on getting kids through the grueling college examinations, obtaining train tickets for major holidays, launching a career in civil service, studying abroad, maintaining healthy food habits, and performing emergency health procedures, among other topics. The advisory messages are often adjusted to specific events, such as disasters, crises, and holidays. In amplifying persuasion, Chinese officials take advantage of the interactive nature of the Internet by inviting netizens to contribute creative content to these platforms, such as happy family photos for "harmonious family day," as well as to consume and repost information in exchange for a chance to win prizes (e.g., Kindles and Apple vouchers). Similar to public relations companies and entertainment platforms, Chinese official news accounts are deploying gaming techniques, playfulness, and interactivity to boost their clicks, views, and social media rankings.

In addition to remolding the existing media channels in the Internet age, Chinese authorities deploy thousands

of paid online commentators and cultivate patriotic bloggers to counteract negative commentaries with persuasive positive messages. Every year, the Chinese government posts about 448 million fabricated posts with the help of these commentators.[11] The paid commentators, known as the 50 Cent Army, operate in a decentralized fashion. Unlike Russian trolls housed within a secretive office compound, China's commentators are hired by multiple agencies and largely work from their smartphones, tracking popular discussions on social media, adding pro-regime content, and at times attacking critical voices.[12] Many of them do this part-time as a source of extra income or as a way of establishing good career connections within the party. Some commentators also work on a voluntary basis out of nationalistic sentiment. The party has singled out and rewarded the most prominent of these grassroots patriots with televised meetings with Xi. The official media constantly glorify the spirit of online patriotism, equating it with good citizenship. Much of the digital patriotism promoted by the state is coming from overseas, with Chinese exchange students (many based in the United States) sharing pro-regime posts, patriotic photos with the national flag, and other nationalistic commentaries. Surprisingly, Chinese exchange students seem to become more nationalistic during their overseas stays, bolstering pro-regime content online, which gets reposted and shared by China's official news platforms and social media platforms.

Overall, Chinese authorities are taking e-governance and digital persuasion very seriously, in some ways mirroring and learning form their Western counterparts. Like Western governments, Chinese authorities are adapting the interactive features of the Internet in their engagement with the public, using digital platforms to gauge and respond to public sentiments and to project a positive image of the government via playful, creative messaging techniques that mask official propaganda. The paid commentators are also not unique to China or to authoritarian systems. While the scale of this phenomenon in China is distinct, many other governments, including the United Kingdom and Ukraine, use troll armies for political persuasion.[13] The co-optation of public opinion through social media, however, is always balanced by containment or restrictive measures on Internet use, which dramatically differentiate the Chinese Internet from its Western counterparts.

*The Stick: Refining Censorship and Surveillance*

Since the introduction of the Internet, the Chinese state has continued to refine and expand its censorship apparatus. Xi has transformed Internet regulation on institutional and tactical levels. Xi created (and chairs) a new Central Leading Group for Cybersecurity and Informatization in charge of defining and disseminating China's cyber strategy. Xi also replaced the State Information Office with the Cyberspace Administration of China—a new state institution in charge of regulating Internet content which directly answers to the president. The emergence of these important, new institutions symbolizes centralization of Internet management, in contrast to more disparate and decentralized Internet regulation in the previous two decades.

The tactics of regulating Internet content have also shifted into a more legalistic and uncompromising direction. Since Xi came to power, Chinese authorities have issued a number of new laws restricting Internet usage. Last year alone, new regulations reined in the use of virtual private networks (VPNs) that helped bypass China's content-filtering system or the Great Firewall. Chinese authorities have further instituted real-name registration on social media platforms, justified by the 2015 Counterterrorism Law, and issued a list of vague categories of forbidden topics to Internet providers, including any discussion that compromises national security or spreads rumors and obscenity.[14] The party-state further encumbered network operators with immense regulatory responsibility under the new Cybersecurity Law, making them directly responsible for monitoring harmful content and storing data in China.

In addition to legal prohibitions, the authorities have launched far-reaching campaigns to weed out "negative elements" from the Internet. The accounts of many online celebrities or public opinion leaders otherwise known as "the big Vs" have been shut down, with some bloggers detained and imprisoned. At the same time, content filtering has intensified, with content featuring even mild political sensitivity being quickly deleted or directed to be deleted via the Internet providers, online news editors, and other gatekeepers. Chinese journalists and editors, for instance, now receive more detailed and frequent censorship instructions, asking them to take out unfavorable content, but also to add positive content, to rephrase and alter their texts. The work schedule of online editors has expanded from an eight-hour day to a twenty-four-hour work cycle.

Despite this intensification of censorship, Internet control remains intentionally partial, as total control would impede official efforts at revitalizing e-governance and persuasion. What we continue to observe in China is an incomplete and sporadic censorship. The authorities are most sensitive to topics that directly challenge the legitimacy of the Central Communist Party and discussions that can spark public mobilization in the form of offline protests or social movements.[15] Discussions about secessionist movements in Xinjiang, Tibet, Hong Kong, and Taiwan, for instance, continue to be completely off-limits, with many Chinese citizens unaware of the umbrella movement in neighboring Hong

Kong or the growth of detention centers in Xinjiang. Any posts commemorating the Tiananmen Square protests are filtered out immediately, as are sarcastic or critical commentaries about top leaders. When it comes to issues in the so-called gray zone of political sensitivity, including discussions of local corruption, environmental degradation, food safety, sexual harassment, and workers' compensation, censorship takes more of a reactive and sporadic nature. Discussions that are devolving into public opinion incidents are more likely to be censored, whereas more dispersed complaints or social media posts are left untouched for longer. Censorship of contentious online discussions, moreover, is often combined with public responsiveness by authorities in the form of policy proclamations widely publicized on social media. As noted earlier, authorities strive toward manufacturing responsiveness, pairing censorship with co-optation. A famous online documentary of China's pollution crisis, produced by investigative journalist Chai Jing, for instance, was censored after it hit over a million views. At the same time, the environment minister complimented the documentary and a number of high-level statements and policies about environmental protection were issued following the online public outcry.[16] Censorship, therefore, while extensive and unpredictable, still succumbs to some patterns and continues to be applied selectively despite the growing institutionalized and legal regulation of the Internet.

In addition to censoring online content, Chinese authorities partake in extensive collection of citizen data in what is likely to represent one of the most sophisticated state surveillance experiments in human history. While data monitoring and collection are publicly attributed to official efforts at improving governance, they also fuel state control over citizens. First, Chinese authorities collaborate with major Internet platforms, like Tencent, to gain access to personal data from popular social media apps such as WeChat, which now boasts over 900 million users. Internet providers are required to store data on China's domestic platforms and to hand it over to authorities at their request. What authorities do with this data and how thoroughly they examine it is unclear. But the access alone means that they can target individuals arbitrarily, especially those with sensitive backgrounds, like members of minority groups.

Moreover, surveillance is becoming institutionalized through China's plan to roll out a social credit system nationally by 2020. Eight tech companies are already running pilot credit-ranking operations to test algorithms and systems for a national project.[17] The existing ranking operations, like Sesame Credit, carried out by Alibaba, display worrisome political undertones. For instance, in addition to more common calculations of financial transactions, Sesame Credit includes a category on interpersonal relationships where you can rank the behavior of members of your social circle, incentivizing self-censorship. Spreading positive energy counts as a credit booster. It is evident that by implementing a national social ranking system, the party-state strives to craft a perfect citizen—the kind who exhibits civilized, law-abiding, politically correct behavior. The social credit system is likely to encourage homogeneity in human behavior, isolating outsiders into the twilight zone of insignificance. Last year alone, the Supreme People's Court banned over six million citizens from taking flights due to their low credit ratings. Such uncompromising punishments will intensify as the system expands. In the name of civility and the rule of law, ironically, Chinese authorities appear to retreat further into arbitrary authoritarian rule.

At the same time, as with all official activities online, the effectiveness of digital surveillance is only partial. The practical implementation of the national social credit system is likely to meet some hurdles as it unfolds. For instance, it remains unclear how the Chinese state will process the immense volume of information it gathers from its citizens and deal with likely technical errors, as well as public crises that can emerge from sudden arbitrary infringements on freedom of movement and access to health care and education. The area of social credit is to be watched closely as the citizen-ranking system unfolds, as it manifests both the opportunities and limitations of technocratic governance that are relevant to democracies as much as to authoritarian systems.

Chinese Citizens: Inhabiting the Censorship Spaces

Like Internet users in Western democracies, the majority of Chinese netizens tend to use the Internet for apolitical activities, such as entertainment and consumption. Peeking into smartphone screens in major cities, you will spot popular TV series, shopping sites, and WeChat discussions. With the advancement of the WeChat platform that encompasses everything from online payments to work and family chats, Chinese citizens are increasingly embedded into and dependent on the Internet for their routine tasks and activities. Phone calls have significantly declined, as Chinese citizens communicate via the instantaneous WeChat platform. Shopping malls are now places to wander, as purchases are largely done online. China's e-commerce trade volume increased by 27 percent in 2017 from the previous year, reaching the volume of $2.03 trillion in the first half of 2017 alone.[18] The dominant players in e-commerce industry, including Alibaba and Jingdong, are using drone technology to transport goods across China, including to remote villages.

Most citizens rarely carry around cash or even credit cards. Even farmers and beggars now use WeChat to pay for their financial transactions. This large-scale

digitalization of society, fueling the data mining and surveillance described earlier, is largely embraced by Chinese citizens. While Western commentators publicize privacy alerts, Chinese Internet users rarely invoke concerns about privacy and tend to associate techno-governance with efficiency and personal comfort. Even the social credit score system described as "Orwellian" by the West has thus far encountered little criticism or pushback from Chinese consumers, with thousands signing up voluntarily for pilot programs to accrue financial benefits.

At the same time, the spread of the Internet procured societal mobilization and public expression impossible in the pre-Internet age. Despite the highly censored and commercialized character of the digital space, Chinese citizens continue to use it for political expression and activism, partaking in what many refer to as the Chinese public sphere. It manifests itself in more overt forms of societal mobilization, as well as in more subtle critical expressions and participation via the use of satire, entertainment platforms, and engagement with rumors.

*Digital Mobilization: Citizen Power*

As for more explicit mobilization, the rise of the Internet has vocalized and connected civil society actors to collaborate on campaigns and to encourage public support for their causes. First, many reputable journalists, lawyers, and intellectuals, who used to only carry a modest following in their respective social circles, evolved into social media celebrities or public figures accessible to the broader society. Some Chinese professors and journalists enjoy millions of followers, produce their own talk show platforms, and spread personal opinion pieces via WeChat circles that they would be unable to publish in mainstream news channels or express in classrooms. Some of these online celebrities take advantage of their following to advocate for specific societal causes. A former investigative journalist turned online activist, Deng Fei, for instance, used the Internet to raise money for a village school feeding campaign that ended up attracting so much public attention that the government itself later stepped up and provided a large sum of funds to complete the project.[19]

Moreover, civil society groups otherwise working in isolation from one another started collaborating online. Journalists unable to publish a sensitive story in their locale spill the information to their colleagues at a larger outlet via social media. Journalists and lawyers, in particular, have built successful alliances on the Internet in advocating for shared causes, such as environmental protection, public construction safety standards, and government transparency. They communicate through WeChat circles, where they share information, publicize each other's causes, and come up with strategies for engaging public opinion and the government on these issues.

Online civil society mobilization also frequently originates from the bottom up. A discussion of a contentious topic can spark on popular social media platforms, drawing attention from civil society actors, who further report on and galvanize the public. Many public opinion incidents introduced at the beginning of this paper follow this pattern. An otherwise local incident turns into a hot discussion topic on social media, drawing attention from public opinion leaders who analyze the incident, publish investigative reports, and offer legal support, putting pressure on authorities to respond. Starting in the late 2000s, most news events have been "broken" on the Internet prior to being reported by mainstream media. In many cases, social media reporting contradicts official accounts of sensitive events, preventing cover-ups. For instance, in the case of the 2011 Wenzhou train crash that took the lives of thirty-eight citizens, mostly of middle-class background, online outcry over fabricated official accounts of the disaster led to the sacking of senior officials at the Railway Ministry.[20] More recently, the Tianjin chemical explosion was widely documented by journalists from online news platforms, like Tencent and Sohu, who broke official regulations on online reporting, rushed to the site, and exposed the disaster to the online public and government officials.

*Indirect Political Critique: Politicized Entertainment*

Chinese citizens also express political sentiments indirectly through satire, entertainment platforms, and rumors. The emergence and popularization of a unique digital culture of online spoofs (*e gao*) or political parodies highlight the important linkages between humor and politics in China's digital expression. Chinese netizens take advantage of the Internet to creatively combine language with images, mixing different media genres and platforms, to come up with catchy memes about hot issues in Chinese politics. Poking fun at the key political slogan under Hu Jintao, the "harmonious society," for instance, social media users posted an image of a river crab, which sounds the same as the word harmony in Chinese, but is spelled with different characters. River crab came to symbolize censorship, with social media users frequently referring to deleted content as "being harmonized." The image went viral, with some reposts featuring expensive watches hanging on the crab, symbolizing widespread corruption of Chinese officials. A recent popular spoof is the public reaction to Xi's elimination of term limits, with netizens reposting an image of Winnie the Pooh as an emperor and of Winnie hugging a jar of honey, headlined "Find the Thing You Love and Stick with It." Chinese citizens can't directly object to these constitutional changes. But they can express momentary dissatisfaction through these playful cartoons and memes, which are

subsequently deleted by the censors. Playful expression is also used to commemorate sensitive events, like the Tiananmen Square massacre. On one recent anniversary, social media users substituted large yellow rubber ducks for tanks in the famous photograph of a sole protester facing the tanks in Tiananmen Square. The image went viral. Eventually, the authorities completely banned the search for yellow ducks online, but it was a tiny societal victory over defining public memory online.

Many of these digital satirical campaigns arise and spread spontaneously in reaction to specific events and go viral via platforms like Weibo and WeChat until they get shut down by authorities. In addition to these spontaneous movements, we are also seeing a rise in satirist personalities or popular comedians online—entertainers who make money from humorous discussions of important societal issues. A well-known example of this is the Papi Jiang show—a female comedian based in Shanghai who started her popular show with a simple phone camera in her living room, speaking at a very fast rate about social issues, from gender inequality to generational conflicts. Her first ad just sold for $3.4 million. She has evolved into one of China's most popular social media personalities.[21] Satirists like Papi Jiang don't touch politics directly, but engage with societal frictions and events that indirectly speak to China's controlled political system.

Other than satire, Chinese citizens frequently partake in creating and spreading online rumors or unverified information. The theme of "fake news" has only emerged in the Western world in the past two years. But in China, the tensions around misinformation have become apparent since the popularization of major social media platforms, like Weibo, in the mid-2000s. Every day, rumors permeate the Chinese Internet on a wide range of topics such as food safety and official corruption, as well as speculations about ways to get rich, fall in love, or buy an apartment in an expensive city. While seemingly innocent, rumors can be political. First, political topics tend to be most prone to rumor creation. During the Bo Xilai scandal, social media were flooded with commentaries speculating on his removal from the party. From high-level scandals to low-grade corruption allegations, political topics unsurprisingly invite public speculation. Moreover, rumors, even if not directly political, challenge the official propaganda accounts by creating alternative narratives and at times even fake scandals that officials have to address under pressure. Many fake food spoofs have emerged recently, with entire businesses destroyed by unverified accounts of fake food ingredients. The political nature of rumors is also evident in the recent official campaign against online rumors, including a crackdown on many social media accounts and even detentions of social media users accused of spreading misinformation.[22] Because of the subtle nature of gossip in contrast to direct provocations, however, rumors are difficult to remove, much less preempt. The so-called fake news phenomenon is unlikely to fade out in China anytime soon.

*Nationalistic Expression: Critical in the Other Direction*

The analysis of Chinese citizens' use of the Internet would be incomplete without an acknowledgment and brief discussion of patriotic and nationalistic expression. As noted earlier, Chinese authorities employ and reward pro-regime commentators who spread patriotic, positive content and counteract negative information online. Though patriotism is strongly encouraged, nationalistic communication has emerged as a double-edged sword for the regime.

In recent years we have seen radical nationalistic waves on the Chinese Internet in response to sensitive international events, at times translating into violent offline protests, hacktivist campaigns, and mounting diplomatic pressures on the party-state to take uncompromising diplomatic positions. In 2012, fueled by online discussions, large anti-Japanese protests erupted across China against Japan's claims over the Diaoyu Islands. In 2016, the election of an anti-China leader in Taiwan provoked China's cybernationalists to "occupy" Taiwanese websites with pro-mainland content. At times, digital nationalism can devolve into hacking attacks. Last year, for instance, Chinese hackers attacked the website of a South Korean conglomerate at odds with Beijing.[23] According to some estimates, there are now 250 patriotic hacker organizations in China.[24] Little is known about the members of these groups and to what extent they are supported by the Chinese government. Studies of online nationalist campaigns, however, demonstrate that many of these emerge from the bottom up and that Chinese authorities often exhibit a mixed attitude toward these movements, complimenting patriotism while censoring more radical nationalism.[25] In the case of the ongoing trade war with the United States, for instance, Chinese authorities try to guide societal nationalism to align with its foreign policy, with its latest directives aiming to quell anti-Trump and anti-American sentiments. Considering that the party's legitimacy draws on establishing a formidable international image of China, however, Chinese authorities cannot and would not want to obstruct digital nationalism, nor would they want to create dangerous nationalistic enemies unsatisfied with the pace of Chinese reforms. Cybernationalism, therefore, presents a dangerous, unpredictable force that the Chinese state will have to handle carefully in the years to come, arguably even more so than liberal expression.

## Conclusions and Implications

An analysis of digital life in China presents the Chinese Internet as a highly dynamic and diverse space, especially when it comes to political expression. Far from being a black box of complete state domination, the Chinese web is negotiated between adaptive and innovative officials and citizens. After unleashing the Internet as a force for modernization and internationalization of Chinese economy and society, Chinese authorities have been forced to adapt to the more destabilizing effects of social media, including threats to the party's monopoly on information and social control. In response, the Chinese state has deployed a complex toolkit of control and co-optation. In particular, under President Xi, we are seeing a regime that treats Internet policy as one of its top priorities in governance, creating new institutions to manage the Internet, passing new, restrictive regulations, co-opting more actors into the wider web of self-censorship, coercing rebels into subordination, and crafting "perfect" citizens via unprecedented data mining operations with the help of Internet operators. At the same time, Chinese authorities increasingly use the Internet as a platform for innovative persuasion by creating online, institutionalized public feedback channels, reinventing the digital news ecosystem, experimenting with creative forms of political expression that use interactive features to lure citizens, and delegating patriotic digital messaging to young citizens in exchange for monetary or symbolic compensation.

While the Chinese Internet has arguably become more politicized and more restrictive in recent years, Chinese netizens continue to take advantage of the web to upgrade their daily lives as well as to express societal and political preferences. As in the West, most Chinese Internet users use the Internet for practical tasks and apolitical communication. In that sense, the official modernization project appears to be working, as most citizens buy into the vision of futuristic techno-governance as superior, dismissing concerns about privacy and surveillance in exchange for speed, efficiency, and instant monetary rewards. China, perhaps, is the best current manifestation of a state-sanctioned digital utopia, where citizens proudly—and for the most part uncritically—embrace technological advancement at all costs.

At the same time, the Chinese web undoubtedly carries important subversive elements, with the emergence of China's public sphere coinciding with the spread of the Internet. Since the early 2000s, we have seen public opinion-makers, including journalists, lawyers, and nongovernmental organization activists, collaborating in shared campaigns online as well as responding to and galvanizing online public opinion movements in vital policy areas, like environmental reform. The Internet created previously nonexistent linkages across activist communities, as well as between activists and the wider public and between the public and officials. Beyond explicit mobilization, Chinese citizens partake in political discussions through satire, entertainment, and gossip—playful expressions that touch upon key sociopolitical issues indirectly. It is debatable to what extent portraying the party as a crab or planting images of yellow ducks to replace tanks provokes any meaningful policy change, but these acts are significant in that they demonstrate to the party public cynicism and dissatisfaction with official propaganda and ideology. In a highly censored system, these symbolic acts allow Chinese citizens to experience some agency and a sense of community in a way that is less threatening than direct political mobilization. This agency, moreover, is not always aimed at pushing for a more liberal and democratic party-state. Some of it is also directed at more nationalistic ambitions, squeezing the state into a bolder, less compromising position vis-à-vis its neighbors and on the global stage more broadly. These diverse online expressions—from public sphere mobilization to playful cynicism to nationalistic campaigns—in turn continue to challenge the party-state to craft an ever more sophisticated cocktail of censorship, regulation, and persuasion.

### *Is the Chinese Internet Unique? The U.S.-China Convergence*

Distinguished Hoover fellow George Shultz has argued that the challenge of the information age is "how to govern over diversity."[26] He referred to the unprecedented diversity of communication flows that governments cannot contain, but have to learn how to manage effectively. While China is often categorized as uniquely authoritarian and technocratic when it comes to Internet governance, I agree with Senior fellow Niall Ferguson's statement that there are more convergences between the two systems than we dare to acknowledge.[27] In particular, I see convergence in challenges, management strategies, and opportunities in the digital sphere. Both China and the United States face unprecedented digital revolutions, which produced diversification of information networks and contestation of the very meaning of "truth." In both countries, trust in traditional media and political institutions more broadly is declining. "Fake news" and rumors have arisen as a dominant force in the information echo system, putting pressure on news organizations and governments to adjust their communication strategies in attempts to instill some order and civility into public discussions and reinstate the notion of "truth."

In both contexts, this campaign for order has been heavily politicized, with the term "fake news" being thrown around conveniently to attack perceived enemies. As part of the anti-rumors campaign, for instance, the Chinese authorities have jailed many intellectuals and

liberal voices deemed dangerous to the regime. President Trump, in the meantime, continues to attach the label of "fake news" to liberal media whenever they criticize him or publish "unfair" reports. This politicization of truth only further inflames political polarization, lowers societal trust, and contributes to more rumor-mongering. In both countries, digital tech giants are being increasingly charged with regulating information flows or censoring inappropriate content. China, of course, practices this at a larger scale and technological sophistication than the United States, but debates over whether and how tech giants like Facebook are going to contain the spread of harmful information are only beginning. This unlikely convergence between the most powerful democracy and the most powerful authoritarian state in the realm of Internet governance is worrisome. It demonstrates how the Internet can play into the authoritarian and populist elements in any society, and how the diversity of information flows that it produces presents an insurmountable challenge to authoritarian and democratic governments alike. We are far from effectively governing over diversity, returning to Shultz's astute premonition.

In placing China and the United States alongside each other in the analysis of Internet governance, however, we also see some elements of positive or democratic convergence between the two giants, with "diversity" of information translating into some meaningful mobilization campaigns for social justice. From the #MeToo movement in the United States to LGBT rights activism in China, the Internet continues to afford unprecedented opportunities for cross-sector connectivity. Some of these movements travel across borders, with the #MeToo campaign recently sparking feminist movements in China and with journalists and environmental activists building transnational networks with their counterparts in America and other Western countries. Of course, such campaigns tend to be more restricted in China, but they are still significant in pressuring authorities to acknowledge and react to societal grievances. Social media have not transformed China into a democracy, but they have arguably contributed to a more politically active society and a more responsive, albeit still authoritarian, state.

*Points of Divergence: Cyber Sovereignty as a Troubling Alternative*

At the same time, China and the United States radically diverge and compete when it comes to the models of Internet governance they promote globally. The U.S. policy of global Internet freedom and openness is increasingly at odds with China's cybersovereignty policy. China aggressively advocates for governments as the key actors in charge of managing the Internet. China promotes a multinational view of global Internet governance, with a coalition of powerful nations enabled to define the boundaries of the global Internet. This strongly contrasts with the U.S.-advocated multistakeholder model, whereby the Internet agenda is shaped by a fusion of nongovernmental actors.

China's cybersovereignty stance poses a number of serious challenges for the United States and for the world. First, China is effectively forcing U.S. Internet giants to comply with Chinese Internet vision if they want to operate in China. Apple CEO Tim Cook's attendance and praise of China at the Wuzhen Internet Forum is one example of the limits the companies are willing to go to in exchange for accessing the China market. Google's recent controversial announcement about a possible reentry into China in exchange for creating a censored search engine is another. In the years to come, we are likely to see more yielding to China by the U.S. techno-giants. Why does this matter? This behavior of U.S. companies delegitimizes the Internet freedom policy advocated by the U.S. government in the eyes of the Chinese party-state and international community and opens more doors for China to deploy the "Western hypocrisy" narrative in promoting its global agenda.
More important, the Chinese cybersovereignty model is becoming attractive to many countries, including poor, developing countries facing security threats and strong states with authoritarian leanings. China is fueling this attraction via the Belt and Road project that includes an important telecommunications dimension, the "digital Silk Road." A joint communiqué from the 2017 Belt and Road Initiative forum called for "harmonizing rules and technological standards when necessary."[28] It is unclear yet what this harmonizing will entail, but it is evident that China's censorship technology and know-how are spreading outside its borders. Ethiopia imported surveillance technology from ZTE that was used to spy on the opposition.[29] China's Golden Shield (or Great Firewall) technology has spread to Vietnam and Thailand.[30] And Russia, one of China's key partners, has been working closely with China through a series of cybersecurity forums to incorporate some of its Internet management strategies. Since 2011's anti-Putin protests, Russia's Internet has become more censored, with some legislation, such as that concerning data storage requirements, mirroring that of China.[31] As we are battling a global populist wave, many democracies look more fragile and amenable to China's influence. This weakness opens doors for China's Internet censorship toolkit to spread to weak democracies, further undermining the Western liberal order. It is unlikely that many countries will be able to fully adopt the Chinese model of Internet control, as it is too costly and elaborate to copy in its entirety. Parts of the censorship apparatus, however, including the overarching shift toward more Internet regulation by governments, are adaptable.

The U.S. government must be vigilant and persistent in responding to China's cybersovereignty policy. First, if we are to uphold global credibility, we need our tech companies to align with the Internet freedom agenda, which means making fewer compromises with China. This will prove difficult, given the allure of the Chinese market, but entering this market doesn't guarantee success. The Chinese government is intent on protecting its own cyber giants, as evident from Uber's recent failure in China. Moreover, if U.S. tech companies are to remain attractive as symbols of Internet freedom, more work is needed to prevent data breaches and rebuild trust with consumers. With Facebook's recent Cambridge Analytica scandal, our tech industry is more associated with corporate greed and monopolization than with Internet freedom. Finally, we have to find innovative ways to engage multilateral institutions and bilateral partners in promoting the multistakeholder Internet governance model. Given China's expanding Internet diplomacy, America has to reprioritize this area, closely watch elements of diffusion of China's Internet practices, and adopt a more preemptive—rather than reactive—approach to China's Internet governance.

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# China's Development Challenge

**By J. Stapleton Roy,** Wilson Center

*Innovation is the primary driving force behind development; it is the strategic underpinning for building a modernized economy.*

*We should aim for the frontiers of science and technology, strengthen basic research, and make major breakthroughs in pioneering basic research and groundbreaking and original innovations. We will strengthen basic research in applied sciences, launch major national science and technology projects, and prioritize innovation in key generic technologies, cutting-edge frontier technologies, modern engineering technologies, and disruptive technologies. These efforts will provide powerful support for building China's strength in science and technology, product quality, aerospace, cyberspace, and transportation; and for building a digital China and a smart society.*

*We will improve our national innovation system and boost our strategic scientific and technological strength. We will further reform the management system for science and technology, and develop a market-oriented system for technological innovation in which enterprises are the main players and synergy is created through the joint efforts of enterprises, universities, and research institutes. We will support innovation by small and medium-sized enterprises and encourage the application of advances in science and technology.*

*We will foster a culture of innovation, and strengthen the creation, protection, and application of intellectual property. We should cultivate a large number of world-class scientists and technologists in strategically important fields, scientific and technological leaders, and young scientists and engineers, as well as high-performing innovation teams.*

– Xi Jinping's 19th Party Congress Work Report, Oct. 2017

**Introduction**

Over the last forty years, China has stunned the world with the brilliant success of its reform and openness policies in modernizing China at a pace never seen before in world history. Forty years after launching these policies, the size of China's GDP measured in purchasing power parity terms has surpassed that of the United States. Per capita income has skyrocketed but lags behind the OECD countries because of the immense size of China's population, now numbering roughly 1.4 billion.

Many factors contributed to this record of success. The massive movement of China's rural population to urban manufacturing jobs vastly increased labor productivity, perhaps by as much as twenty times. The introduction of market forces into China's hitherto planned economy gave a further boost to productivity since the manufacturing efficiency of China's private sector exceeded that of the lumbering state-owned enterprises by as much as three times.

Devastated by the Great Cultural Revolution, China's educational system rose to the challenge, reformed and reorganized itself, and began churning out vast numbers of scientists and engineers, many of whom "plunged into the sea" of private sector enterprises. Hundreds of thousands of China's best students flooded the West's premier universities, gaining language skills along with much needed scientific, engineering, and management skills. The attraction of China's huge domestic market enabled Chinese joint ventures with foreign partners to demand and get access to valuable intellectual property.

The biggest challenge facing China's leaders is how to sustain this pattern of success in the decades ahead. China's goal is to raise the country's per capita GDP to OECD levels by mid-century. They face formidable obstacles. The GDP growth rate has slowed from double digits to the vicinity of six percent, impressive by world standards but barely sufficient to meet China's ambitious goals. The work force is beginning to shrink. The population is aging rapidly, with a national social welfare system still in the process of formation. Polluted air and water throughout the country now pose major health hazards. Vast areas of China face acute water shortages.

China has detailed ambitious plans for a new leap forward by seizing a leading position in utilizing the capabilities of the information revolution and new leading-edge technologies, such as artificial intelligence and robotics. If China makes significant progress towards fulfilling its ambitious plans to harness artificial intelligence, robots, and other advanced technologies to meet its development goals, the United States for the first time

since its rise to global power will face a competitor whose economic, military, and intellectual resources are greater than its own.

**China's Rapid Rise and Development Challenges**

In a three-hour speech at the 19th Communist Party Congress, General Secretary Xi Jinping proclaimed China's rightful return to the center of the world and projected that by 2035 China will "become a country whose comprehensive national power and international influence will be at the forefront." By mid-century, the People's Liberation Army is expected to be one of the world's top-ranked militaries. When these goals are met, "the Chinese nation will stand tall among the nations of the world with an even more high-spirited attitude."[1]

Since Reform and Opening (改革开放) in 1979[2] until 2017, China's economy grew an average of roughly 10 percent annually.[3] According to the World Bank, this was "the fastest sustained expansion by a major economy in history—and lifted more than 800 million people out of poverty."[4] With a population of over 1.4 billion people, China plays an increasingly important role in the global system. China now has the highest foreign exchange reserves globally.[5] It also leads the world in terms of manufacturing output.[6] According to Deloitte's 2016 Global Manufacturing Competitive Index, China is the most competitive manufacturing nation in the world.[7]

China's precipitous growth over the last quarter century, however, has spawned several challenges that threaten to derail future growth and lead to instability. Some of the challenges are immediate, such as pervasive corruption, unequal wealth distribution, life-threatening air and water pollution, and a slowing economic growth rate. Others are long-term but do not loom far down the road. These include the impact of climate change, escaping the dreaded middle-income trap, and adverse demographics exacerbated by the one-child policy.

*Environmental Pollution*

Toxic air and water pollution are foremost on the minds of policymakers in Beijing. The emphasis on energy-intensive and high polluting industries to maintain rapid economic growth has culminated in what many term "Airpocalypse".[8] The U.S. Embassy in Beijing reports on air quality in the city based on a monitor to measure PM 2.5 particulates, which are "fine" particulates in the air small enough to directly enter the lungs and blood stream.[9] The readings are converted into an air quality index (AQI) that outlines levels of health concern ranging from "good" (0 to 50 reading) to "hazardous" (301 to 700 reading).[10] In January 2013, the embassy reported an AQI level of 755, calling it an unprecedented "Beyond Index" reading.[11]

A 2017 OECD working paper estimated the economic cost of air pollution to China in 2015 at USD $1.5 trillion, equivalent to 7.9 percent of its GDP.[12] The RAND Corporation measured the economic costs of air pollution in terms of health impacts and loss of labor productivity and estimated a 6.5 percent loss of China's GDP each year between 2000 and 2010.[13]

Water scarcity and pollution is a much more serious problem. China is home to 1 out of every 5 people in the world, but only has 7 percent of the world's fresh water reserves.[14] And it is depleting. According to Columbia University's Earth Institute, China's freshwater reserves declined by 13 percent between 2000 and 2009.[15] The country had 50,000 rivers with catchment areas of 100 square kilometers or more in 1950s. That number went down to 23,000 in 2013 as a result of agricultural over-use and factory pollution.[16]

What little water remains is either used to mine and process coal (20%) or for agriculture (about 70%), industries which are heavily concentrated in the arid northeast of China where patterns of rain and snowfall are already being disrupted by climate change.[17] Just this past winter, Beijing endured a historic 145 consecutive days (between October 23rd and March 17th) without rain or snow, its longest dry spell in 47 years. The economic loss in 2016 from extreme weather events such as droughts, flooding, and landslides in China was estimated at 503 billion yuan (USD $72 billion),[18] up from 421 billion yuan (USD $69 billion) in 2013.[19]

*Demographic Factors*

One of the key drivers of China's rapid economic growth has been the overabundance of young, underemployed workers. This human goldmine meant firms in China had access to a nearly endless supply of cheap labor, which resulted in healthy profit margins that in turn, boosted investment and production. This is no longer the case as the country's fertility rate plummeted because of demographic policies such as the one-child policy, from a high of 6.4 births per woman in 1965 to a low of 1.5 in 2000.[20] Fertility rates ticked up to 1.6 in 2013 (the same year China relaxed the one-child policy) but many experts believe "low fertility is here to stay" with rates remaining below-replacement levels for years to come.[21]

Less people means a tighter labor market. Although China's working-age population (people 15-64) is still substantial compared to other economies at just under one billion, experts believe China's labor pool is shrinking.[22] McKinsey Global Institute predicts China's labor force will peak as early as 2024 and shrink by one-fifth in the next 50 years.[23] The diminishing supply of cheap labor will result in higher wages and make Chinese firms less competitive. Exacerbating the problem is the simultaneous increase

of pensioners (people over 65) in China. By 2050, there will be 400 million Chinese citizens over 65 and 150 million of these will be over 80 years of age.[24] According to Bloomberg, pension contributions by workers stopped covering retiree benefits since at least 2014, forcing the government to make up the difference. With pension expenses rising 11.6 percent to 2.58 trillion yuan in 2016, many consider China's aging population the "next debt bomb."[25]

**China's Planning Process**

One of the key strengths of China's governing system is the role of planning in managing foreseeable contingencies and mitigating the risks associated with them. China's planning system is constantly running but kicks into full gear every 5 years for the drafting of the Five Year Plan (5YP). The current (13th) YP is the first to be drafted under President Xi Jinping's watch and reflects not only his desire to make China great again but also a sober recognition of the challenges China faces in the coming years.

The government's laser-like focus on the environment is on full display in the 13th 5YP. Quantitative targets related to the environment and resources account for almost half of all targets. More importantly, every single target is mandatory.[26] The current plan builds on a sea change in public awareness of environmental issues. It was not until after the U.S. Embassy in Beijing started releasing air pollution data that Chinese citizens started to be concerned about air pollution. The Chinese public is now much more knowledgeable and aware about the environmental situation in China and is more vocal about it. They now require not only the monitoring of air pollution and polluting sources, but also clarification of responsibilities and roles of the public and private sectors in addressing environmental issues. The 13th 5YP addresses these concerns head on.

Progress in in the air, literally. The 2013 "airpocalypse" was too obvious to ignore and prompted Chinese Premier Li Keqiang to "declare war against pollution" in 2014.[27] Since then, China's state-backed planning system has led to a dramatic decrease in PM-2.5 levels across the country. According to The Economist, Beijing saw a 54 percent decrease in PM-2.5 levels from 2016 to 2017, while concentrations in 26 cities across northern China saw a 30 percent decrease.[28]

*Made in China 2025*

In 2013 the Chinese Academy of Engineering and the Ministry of Industry and Technology lead a research team of 50 scholars and over 100 experts to identify weaknesses in China's industrial policy. The comprehensive study of China's manufacturing sector and overall competitiveness was meant to address long term development challenges, such as shrinking productivity and a declining labor pool. Two years later in 2015, the "Made in China 2025" plan was born (hereafter China 2025).

China 2025 is a blueprint on how Beijing plans to transform the country into a "world manufacturing power" and avoid the middle-income trap. The plan identifies and highlights priority sectors that will increase competitiveness in the long-run. These sectors are meant to guide local governments and enterprises in their investment and business decisions, many of which suggest significant policy support for disruptive technologies that fall under the rubric of Artificial Intelligence (AI). These include: Next-generation information technology, high-end numerical control machinery and robotics, energy-saving and new energy vehicles, and biomedicine. Other industries, such as smart grids and new energy vehicles are singled out as areas to improve indigenous research and development.

The major theme running through both the 13th 5YP and China 2025 is sustainable and equitable growth through innovation and advancing technologies. Not surprisingly, both plans identify emerging technologies as a national priority, thus throwing substantial policy support behind the development of artificial intelligence and robotics.

**Artificial Intelligence**

China and the United States are poised to dominate the world of artificial intelligence for the next several decades. The struggle between them to capture and retain the lead position in AI will widen the gap between them and the rest of the world. AI talent and research labs are widely distributed, but only China and the United States have the huge data sets necessary to train the deep learning-based AI systems of the future. PriceWaterhouseCoopers has estimated that the United States and China are likely to capture 70 percent of the $15.7 trillion that AI will add to the global economy by 2030, nearly half of which will go to China.[29] Not surprisingly, of the seven AI giants (Google, Facebook, Amazon, Microsoft, Baidu, Alibaba, and Tencent), four are American and three are Chinese.

China will be a formidable AI competitor to the United States. In large measure, this is because China's pioneering startup internet companies were able to rise above one of the principal liabilities of a copycat culture, which is the inhibiting effect this has on innovation. Lacking protection for intellectual property, China evolved a three-stage process: 1. Ruthlessly copy or clone a foreign (usually American) internet application to build engineering skills; 2. Adapt the application to suit Chinese conditions; 3. Innovate to stay ahead of competitors who have ripped off your own application in China's no-holds-barred entrepreneurial marketplace. This process was unethical but effective. China was short of top-flight internet engineering skills but had an abundance of computer-science trained talent. This was the raw material that permitted market conditions

in China to generate a host of entrepreneurial skills in a survival of the fittest competitive free-for-all. In the words of Kai-Fu Lee, "Algorithms tuned by an average engineer can outperform those built by the world's leading experts if the average engineer has access to far more data." This underscores the importance of big data for AI success, an advantage that China shares with the United States.

China's rulers are also encouraging heated competition among municipalities for AI investments, a function that is left primarily to the private sector in the United States.

Special note should be made of the lightning-quick spread of mobile payments in China, where in a short three-year period since its first deployment in 2015, people are now paying for groceries, massages, movie tickets beer, and bike repairs with their smart phones. This is generating an enormous harvest of data that can support AI-driven companies in retail, real estate, and other areas.

**Robotics**

China has been the world's largest robotics market since 2013, but its robot density still lags behind the global average. China intends to change this. Made in China 2025 identifies the robotics industry as a strategically important sector. It is launching a two-pronged drive: first, to seize a leading position in manufacturing robots by raising the global market share of Chinese-made robots from 31 percent in 2016 to over 50 percent by 2020; and second to raise productivity by promoting robotics-enabled automation in key industries, including automobile manufacturing, electronics, household electrical appliances, and logistics. To further these objectives, the PRC Ministry of Industry and Information Technology announced this year that China has "approved a plan to build a national robotics innovation center, which will focus on tackling common bottlenecks such as human-machine interaction technologies and compliant control."

The statistics for 2017 are revelatory. China purchased 141,000 industrial robots in 2017, a near 60 percent increase year-on-year. However, nearly three-quarters of these purchases were from foreign companies, who sold nearly 104,000 robots to China that year. 65 percent of the robots sold in China were articulated robots, up two-thirds from the previous year. 42 percent of the robots sold by domestic suppliers were articulated robots, up 35 percent. China's industrial market for robots is estimated to reach USD $5.9 billion by 2020. Robot applications are concentrated in automobile manufacturing, electrical and electronics, rubber plastics, metallurgy, food, chemical engineering, and medicines and cosmetics. Automobile manufacturing uses half of these robots, with over 50 percent in welding applications.[30]
Some experts believe that the spread of robots in China could subject it to widespread economic and social disruptions because over 25 percent of Chinese workers are still on farms, as compared to less than 2 percent in the United States.[31] Others believe that the impact of robots on factory employment will be slowed and mitigated by the difficulty of adapting robots to manufacturing jobs requiring intelligent decisions. In the words of one such expert, "This is because the intelligent automation of the twenty-first century operates differently than the physical automation of the twentieth century. Put simply, it's far easier to build AI algorithms than to build intelligent robots."[32] This argument rests on a tenet of artificial intelligence known as Moravec's Paradox, which holds that it is relatively easy for AI to mimic the high-level intellectual or computational abilities of an adult, but it is far harder to give a robot the perception and sensorimotor skills of a toddler.

**Military Factors**

The implications of breakthroughs in artificial intelligence and robots are best illustrated in the military field, where a sudden technological advance by an adversary could have devastating implications for national security even though the impact on productivity and jobs would be of lesser consequence. Examples from the past include the development of nuclear weapons and intercontinental ballistic missiles, both of which were game-changers in terms of defense concepts.

For seventy years the United States has enjoyed overwhelming air and naval dominance, but it is burdened with legacy systems, many designed a half-century ago, that are likely to be highly vulnerable in the warfare of the future. Such warfare between high-tech opponents is likely to be fought with cutting-edge "smart" combat systems driven by artificial intelligence, with cyber-weapons, and with robots that can operate on the land, in the air, and in and under the seas. Such combat could feature hypersonic weapons, electromagnetic kinetic weapons with muzzle velocities of 5,000 miles per hour, and directed-energy laser-based weapons.

Not surprisingly, China is pouring impressive resources into developing the weapons technologies of the future. It is pursuing the twin goals of having the capability to disrupt and degrade the information systems on which our military depends, while gaining a leading edge in the technologies that can shift the balance of future economic and strategic power. Its successful testing of an anti-satellite weapon in 2007 is indicative of this effort. In a paper published in June 2018, former Navy Secretary Richard Danzig noted the fear among experts on digital technology regarding "our present pervasive (and expanding) dependence on a technology so vulnerable to subversion. Experts know how to achieve information

integrity, availability, and confidentiality in small systems, but their ability to secure these essentials does not scale."[33]

China is targeting this vulnerability. It is paying particular attention to artificial intelligence and quantum technologies, claiming that it has already tested a quantum radar than can identify stealth aircraft. In testimony to Congress in January 2018, William Carter noted that China's national strategy anticipates a shift from today's "informatized warfare" to "intelligentized warfare," based on gaining a dominant lead in key commercial industries in artificial intelligence, quantum technology, augmented and virtual reality, and robotics.[34]

**Conclusion**

Since the first half of the 19th century, China has paid a heavy price for its technological backwardness in comparison with western countries. Its traditional culture stifled innovation. Its military backwardness enabled stronger powers to reduce China to a semi-colonial status. Its economy was deficient in capital and management skills. Its domestic scene was convulsed with insurrections, civil wars, and foreign interventions.

Ironically, recent decades have demonstrated that backwardness can pave the way for giant leaps forward by bypassing the slower development stages of more advanced countries. Chinese productivity was held back for a century by the unsuitability of the Chinese language for typewriters. Now computers have removed that problem, giving China a giant boost in productivity in producing documents and other written materials.

China leaped in a few decades from the wide spread scarcity of wired telephones to a nation-wide cellular system. China is bypassing credit cards by using mobile phones for digital payments (China's payments via mobile phones during 2017 are estimated to exceed $17 trillion, over fifty times greater than comparable transactions in the United States). Internet penetration is the highest in the world for a developing country. A slow, crowded, and unreliable rail system has been transformed in less than fifteen years to a national system of high-speed trains that would be the envy of any country in the west.

Nevertheless, China faces formidable obstacles in seeking to achieve its centenary goals. For analytical purposes, these can be divided into discreet categories that will contribute to better understanding of their potential impact on China's future development.

First, there are problems such as an aging population, a declining work force, environmental degradation, a widening gender imbalance, a slowing rate of urbanization, the middle income trap, and the potential for new technologies, if implemented haphazardly, to create widespread unemployment. Such problems have frequently been cited as dimming the prospects for China to achieve its millennial goals. However, daunting as these problems may be, their implications can be anticipated and kept manageable through a disciplined planning process that develops policies and allocates the resources necessary to address them effectively. China has both the experience and the planning institutions to address such problems, provided that the leadership assigns them the necessary priority. Breakthroughs in the new technologies could also be instrumental in successfully traversing the middle income trap.

Second, there are problems such as changes in rainfall patterns and river flows, sea level rise, the melting of the Himalayan glaciers that feed most Asian continental river systems, and the increasing scarcity of the fresh water resources required by China's massive population. These problems can be anticipated but are on a scale that could readily swamp even a disciplined planning process. Nevertheless, their onset is gradual, and in some cases the disruptive consequences emerge incrementally. Particularly troublesome would be prolonged climate-change-induced drought in key agricultural areas and the problem of inadequate fresh water. Breakthroughs in desalination and water treatment are unlikely to provide solutions on the scale necessary to meet the needs of China's population. Disputes with down-stream countries dependent on water resources originating in China are also likely to become more acute.

Third, there are external variables over which China has only a limited degree of control. These include unanticipated military conflicts, global recessions or financial crises that adversely affect China's export markets, disruptions in energy supply lines, or determined efforts by countries such as the United States, individually or within broad coalitions, to hinder China's modernization process. This latter possibility must now be taken more seriously in the light of recent negative attitudinal shifts in the United States towards China's modernization process.

Finally, there are domestic imponderables, most centering on the crucial issue of stability and the ability of China's leaders to shore up the legitimacy of communist party rule. China under Xi Jinping is reversing the direction of the Deng Xiaoping-sponsored reform and openness policies that underpinned its rapid economic development. A key element of these reforms was the retreat of the communist party from its earlier insistence, carried to a ridiculous extreme in the Great Cultural Revolution, on controlling every aspect of the lives of Chinese citizens. For thirty years Chinese have enjoyed significant freedoms in thought and movement.

Now the party is again seeking to tighten ideological controls over the Chinese people and has put on hold the decisions at the Third Plenum of the 18th Central Committee in 2013 to make the market the determining factor in setting prices and allocating resources. This is certain to exacerbate the principal anomaly in China's development process, which is the contradiction between the party's success in modernizing the social and economic foundations of the country and its refusal to modernize the political system.

Unlike the Soviet Union, China's economy is not autarchic. Sustaining rapid economic growth is heavily dependent on unhindered access to foreign sources of energy and raw materials. Moreover, since China's entry into the WTO in 2001, the country's burgeoning foreign trade and robust inflows of foreign direct investment have added several percentage points to China's annual GDP growth. A major challenge for Chinese diplomacy is to ensure that these inputs, essential for sustaining rapid growth, are not disrupted. If China becomes increasingly dependent on domestic repression to maintain stability this could adversely affect China's progress towards its centenary goals.

To a significant degree, this hinges on the question of whether this reversal of direction under Xi Jinping will ensure stability in the decades ahead or will make China more difficult to govern. Views on this issue differ widely. In an essay on "Central Issues of American Foreign Policy" published fifty years ago, Dr. Henry Kissinger noted that "The dominant American view about political structure has been that it will follow more or less automatically upon economic progress and that it will take the form of constitutional democracy."[35] Dr. Kissinger took issue with both aspects of this proposition, arguing that "the system of government which brought about industrialization—whether popular or authoritarian—has tended to be confirmed rather than radically changed by this achievement." Nevertheless, variants of the optimistic point of view that rapid economic development leads to political liberalization remain prevalent in the United States, although roundly denounced by denizens of the "realist" school.

The political outlook for China is clouded by the malaise that has afflicted many western democracies, including the United States, in recent years, making them less effective in addressing key governance issues such as rising budget deficits, skewed income distributions, immigration policies, and preserving traditional freedoms in the face of rising terrorist threats. During the 1990s, a convincing case could be made that every modern developed country had a representative form of governance and a market-based economic system. This suggested that the modernization process itself fostered political liberalization. Developments over the last fifteen years, including the global financial crisis in 2008, have made that case less compelling and rekindled the contention that well-managed authoritarian systems can out-perform democracies with market-based economic systems.

Since becoming China's top leader in 2012, Xi Jinping's primary challenge has been to restore the legitimacy of communist party rule in a country that has been radically transformed in its economic and social structures by the success of the Deng-launched reform and openness policies. The Bo Xilai scandal in the final year of Hu Jintao's leadership blatantly exposed the rot of corruption that has infused the party from top to bottom. Xi Jinping's relentless anti-corruption campaign is seeking to address this problem, but it has barely dented the surface. Nor has it addressed the vast accumulation of wealth in the hands of top communist party power holders.

A central element in his campaign to restore the party's centrality in managing China's domestic affairs is Xi Jinping effort to address the admission in the 19th Party Congress work report that "struggles in the ideological field remain complex." His principal weapon has been his campaign to discredit western models of development and concepts of governance, insisting that everything must have "Chinese characteristics." This is also reflected in the affirmation that the communist party must be above the law and answerable only to itself.

To force China onto this retrograde path, Xi Jinping is relying on fear and repression to a degree that has no parallels in the last thirty years. Extra-judicial arrests and abductions, tighter controls over Chinese students studying abroad, more restrictive ground rules for foreign travel, massive reeducation campaigns for restive minority populations, all have become features of the new order under Xi Jinping.

Less well appreciated is the fact that China is approaching an important leadership inflection point. Xi Jinping is the last of China's top leaders with some semblance of revolutionary credentials, in that he is a member of the "red second generation," i.e., the children of revolutionary leaders. There is no "red third generation." All previous Chinese communist top leaders either had revolutionary credentials themselves, or were selected by party elders with such credentials, as in the case of Jiang Zemin and Hu Jintao. Xi Jinping's father, in his early twenties, was deputy commander of the communist guerrilla forces in northwest China when Mao's weary forces arrived in Yan'an at the end of the Long March.

To cite an American parallel, even well-educated Americans have difficulty recalling the names of the American presidents between John Quincy Adams and Abraham Lincoln. The successors to Xi Jinping will

also be persons of lesser stature, meaning their claims to the mantle of leadership will lack any revolutionary underpinning. This was undoubtedly a factor in removing the age limits from the party constitution that would have prevented Xi Jinping from continuing as President of China beyond 2022. There are three leaders on the 19th Politburo that are young enough to serve ten years beyond 2022, but none of them was considered sufficiently capable as a successor to cope with the mounting challenge of shoring up the legitimacy of continued communist party rule in China.

Over the last forty years, this legitimacy has rested on the communist party's success in providing the stability necessary for the rapid economic development that has brought undreamed of prosperity to vast segments of China's population. Success in mastering the new technologies may be helpful in moving China out of the middle income trap but cannot assure political stability. That will depend on the quality of China's leaders and the correctness of their assessment that they can preserve authoritarian rule while continuing to modernize the country.

This poses a major policy challenge for the United States. If China makes significant progress towards fulfilling its ambitious plans to harness artificial intelligence, robots, and other advanced technologies to meet its development goals, the United States for the first time since its rise to global power will face a competitor whose economic, military, and intellectual resources are equal to or greater than its own. But history does not move in straight lines.

China's domestic contradictions are worsening, but the communist party's instruments of control and suppression remain strong and under firm party control. Rash predictions of China's imminent collapse are gathering dust on bookshelves. We cannot assume that tighter political controls in China will prove incompatible with the country's current vibrant entrepreneurial culture in AI-related fields.[36] The key question for the United States is whether efforts to hinder China's modernization process can be an effective strategy in the absence of a more determined effort to address our own domestic deficiencies.

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[30] See "The Robotics Industry in China, May 14, 2018, by I-Ting Shelly Lin.

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[32] *AI Super-Powers: China, Silicon Valley, and the New World Order*, Kai-Fu Lee, Houghton Mifflin Harcourt, 2018.

[33] "Technology Roulette: Managing Loss of Control as Many Militaries Pursue Technological Superiority," Richard Danzig, Technology & National Security, June 2018.

[34] Statement Before the House Armed Services Committee, Subcommittee on Emerging Threats and Capabilities: "Chinese Advances in Emerging Technologies and their Implications for U.S. National Security," A Testimony by: William Carter, Deputy Director and Fellow, Technology Policy Program, January 9, 2018.

[35] This essay was first published in "Agenda for a Nation," The Brookings Institution, Washington, D.C., 1968. It was subsequently included in *From American Foreign Policy: Three Essays by Henry Kissinger*, W. W. Norton, New York. 1969, pp. 51-97.

[36] For a more in depth look at this questions see: *End of an Era: How China's Authoritarian Revival is Undermining Its Rise*, Carl Minzner, Oxford University press 2018

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# Observations from the Roundtable

Aspirational goal-setting has been a motivating form of governance for the Chinese Communist Party (CCP). In a 1957 international meeting of communist leaders in Moscow, Nikita Khrushchev proposed a goal that the Soviet Union catch up with U.S. industrial output within 15 years; Mao Zedong countered, in turn, that within the same time frame China would not just catch up with but surpass the United Kingdom. The result was the disastrous Great Leap Forward and its resulting famine.

But the CCP has also adopted pragmatic frameworks. For example, founder of modern China's reform movement Deng Xiaoping colorfully described the country's process of reform and opening as an incremental "crossing the river by feeling the stones." And that history has been extremely fruitful. China's GDP has grown from just 11 percent of that of the United States in 1997 to 63 percent just two decades later. Since the 1980s, 800 million people have lifted themselves out of poverty in China, alongside a population that has gone from overwhelmingly rural and poor to mostly urban and medium income.

Today, a combination of changes that are larger than any single leader or development plan have set up new challenges ahead for China—some of which are unprecedented both in China's own modern history and in all of human history:

One known cross-current is demographic, reported on at length in this volume. The size of China's working age population has for decades been growing at an average annual rate of 1.8 percent. But China's workforce has peaked and begun to fall, and by 2040, it will be falling by 1 percent annually.

Governance is another challenge. The party has taken control of new information and communications technologies both to monitor the views of citizens and, to some extent, to respond to their concerns. Moreover, it uses these technologies as a means of censorship and surveillance to enforce authoritarian rule. In some ways the party's responsiveness has enhanced the social contract; at the same time it has enabled more complete repression of the citizenry's ability to mobilize and take action. The contradiction between economic flexibility and rigid single party political control may loom large in China's future.

China's growing economic weight and military capability are also changing the nature of how it balances alongside other global powers. As China increasingly "goes out" into the world, how will those strengths develop?

Meanwhile, air and water environmental degradation continues to vex social satisfaction levels and act as a shadow tax on health and economic wellbeing. Even in a modern, urbanized China, the gap in cross-cutting environmental performance remains one of the starkest differences with advanced countries such as the United States.

Understanding what these challenges mean for China into the future—and therefore how the United States should position itself——raises the following question: does China's prominence in twenty-first century technologies such as artificial intelligence, advanced manufacturing, and information technologies now provide an auspicious chance for it to overcome the demographic, environmental, and other headwinds it faces and join the ranks alongside other global advanced economies? Similar challenges have historically hobbled the development of middle-income countries, but they lacked access to these promising new toolsets.

The papers prepared for this volume and expert discussion at the ensuing Hoover Institution roundtable illuminate this question. They argue that the challenges facing China are profound, but the regime's adaptation of recent technological innovations has created a stronger and more responsive authoritarian state that will likely pose challenges for the United States in many dimensions.

**Demographics**

China's period of reform and opening coincided with a demographic dividend in which the working age cohort increased its share in the overall population relative to dependents such as children and the elderly. Together with a large productivity-increasing rural-to-urban migration and commensurate education improvements, these forces helped underpin four decades of 10 percent annual economic growth. While we cannot predict the future of

technological progress or political reforms, absent a catastrophic event, China's demographic future through 2040 is essentially set:

- Decades of low fertility—following a sharp decline in the 1980s—means that China's working age population (15-64) peaked just before 2015, is now shrinking, and will continue to shrink with growing speed.
- Specifically, the pool of potential young workers (ages 15-29), which are the best educated, most tech savvy, and most flexible in terms of working arrangements, is shrinking sharply.
- The 30-49 cohort—which has been observed historically as a peak age for innovation and high intellectual achievement—is also shrinking.
- Meanwhile, the 50-64 cohort—the least educated and healthy of China's workforce—is growing but will start to shrink in number by 2040.

And with rising longevity, the elderly population over 65 is exploding. The pool of dependent seniors is growing by 3.7% per year, from 135 million in 2015 to 340 million in 2040, at which point it will comprise 22% of the population, making China a "super-aged society."

These demographic headwinds imply that the coming generation will not see the phenomenal economic rise of the last without radical productivity-improving interventions: as Nick Eberstadt observes, "the demographic dividend has already been cashed." They also introduce new pressures that could lead to social and political instability.

For example, how will China provide for the immense population of future seniors? Other countries, including the United States, face similar challenges, but the scale and intensity is considerably smaller. Today's rudimentary and uneven pension and health system does not cover many Chinese seniors, yet the current unfunded pension and health liabilities are already comparable in scale to the country's annual GDP. Traditionally, the elderly would rely on their children and families to support them. However, the small size of most Chinese families—a product of low fertility, whether forced or otherwise—limits their ability to perform that traditional caretaker role. The elderly will furthermore be concentrated in rural areas where social services and other resources are weakest. Rural China, in particular, is set to become one of the "greyest" populations ever observed in history. Caring for the elderly could lead to substantially increased welfare spending going forward, reducing resources available for other productive investments or geopolitical priorities such as foreign lending or military modernization.

Meanwhile, China continues to rely on domestic migration from rural to urban areas to maintain the workforce, both within provinces from villages to mid-sized cities and across provinces from the inner hinterlands to coastal megacities. Migrants, more than 40% of the urban population, are engines of economic growth. But they remain largely second-class citizens without urban residency status. Granting entitlements such as education rights for children of migrants could also redirect city budgets that have in recent years otherwise been available for large spending projects on infrastructure or security regimes.

Finally, there is the impact of extremely low fertility rates on social structures. As early as 1990, for example, four-fifths of children born in Shanghai were only children, themselves now having their own only children. This has led to the creation of an inverted "new family type" in China without any siblings or extended relatives—only ancestors. It has also led to a gender imbalance: by 2030, 20 percent of Chinese men in their early 40's are expected to be never-married, up from just 4 percent in 2000. This new dynamic causes parents to devote immense resources on their child's upbringing but also could generate a growing sense of social risk-aversion where the potential loss of sole lineage-bearers becomes intolerable. The Chinese government is aware of these demographic challenges. It continues to emphasize urbanization as an engine for productivity growth, as well as education, and has taken more radical steps to try to affect culture: the wave of thousands of state-sponsored tech incubators in recent years has shifted modern Chinese attitudes towards embracing entrepreneurial risk-taking.

But the scale of these overall changes suggests that demographics will continue "to bound the realm of the possible." Growing acceptance of immigration in a historically closed society may help China attract top "quality" workforce participants, but even large flows from China's smaller neighbors cannot appreciably impact the "quantity" question. Meanwhile, any future pro-natal efforts by the state are likely to be as ineffective as they have been in other East Asian countries—unless China discovers new ways to use twenty-first century social monitoring technologies to incentivize or coerce its citizen's behavior to these ends.

**National Security Implications of Advancing Technology**

In the military arena, China sees an opportunity to use twenty-first century technologies as one route towards overcoming the United States' traditional dominance—one which they see as based on legacy systems potentially vulnerable to warfare of the future, including cyber weapons, artificial intelligence-enhanced information systems, and autonomous platforms.

Elsa Kania points out that artificial intelligence in particular has emerged as a new focus of competition between the United States and China: prowess in machine learning and big data has strategic significance for both economic development and military modernization. And this competition feeds on itself: current U.S. superiority, demonstrated by AlphaGo's surprise victory over the best human Go players, stimulated China—the overtones of dominance in this traditional game of military strategy did not go unmissed to Chinese observers. The United States' own pursuit of AI for national security purposes is in turn stimulated in part by China's massive investments in this technology. Both parties believe AI could be revolutionary, and that it could disrupt the military balance. China seeks the "intelligentization" of its military—wherein it uses data and machine learning to inform operational decision-making, enable new capabilities, and even change its force generation models—in order to augment its forces and become capable of fighting, and winning, on the modern battlefield. At present this is largely an aspirational goal supported by research, development, and verification that will play out for years to come. To do this, China both closely studies U.S. defense innovations and is mobilizing its own domestic firms and universities to support military use of advanced technologies. For example, the PLA is now supporting a range of projects involving applications of artificial intelligence and related technologies for target recognition, electronic warfare, resilient communications, cyber security, and defensive and offensive systems. The PLA is pursuing autonomous vehicles—for air, sea, and land operations—enabled by machine learning and additive manufacturing, including swarming capabilities as an asymmetric counter to U.S. legacy platforms. It is also exploring use of artificial intelligence to support rapid decision-making. China already contends with the United States for superiority in the global military UAV market and is home to the largest manufacturer of commercial drones.

More broadly, it is important to appreciate that the combination of artificial intelligence and cyber warfare could potentially escalate future conflicts. Complex artificial intelligence systems involved in decision-making and operations could make mistakes, as they do, triggering decisions with unintended and perhaps escalatory consequences. And going forward, both China and the United States may in fact share similar vulnerabilities as advancing technologies make asymmetric weapons systems across various domains more accessible to less sophisticated players. The United States and China would be wise to continue track two and eventually military-to-military dialogues to reduce risk in this area.

**Advancing Technology and the Chinese Economy**

In artificial intelligence, China sees an opening to move beyond its fast-follower economy. As Kai-fu Lee and Matt Sheehan observe, the Chinese government and firms are joining others around the world in exploring the new "plateau" that has been created by recent advances in machine learning and big data. Chinese productivity in the period of reform and opening and rural-to-urban migration has already increased by 20 times. As demographic and other economic challenges now loom, one goal is to apply these new technologies throughout many sectors to help extend such growth.

Enthusiasm in the country is heightened by a sense that China may in fact have comparative advantages in the application of artificial intelligence throughout the economy. Early in the 21st century, following decades of research and building on an explosion of digital data and advances in computing power, machines became able to learn from the data, recognize patterns, and predict the best answers, allowing them to take on many tasks such as driving a car, diagnosing a disease, and making a loan. This advancement marked the culmination of a period of great "discovery," which favored the most elite research institutions at universities and global companies, such as those in the United States. Now, however, the focus of the field may be shifting towards "application" of this technology, which could play to Chinese strengths:

This period of implementation favors the engineer, not the scientist, and China produces large numbers of well-trained, competent engineers to fill the ranks of startups and large companies.

Vast amount of data, the raw material for machine learning, are being generated as Chinese citizens willingly funnel a growing portion of their daily activities through their smart phones, providing Chinese companies a deep and multi-dimensional picture of their lives.

The U.S. technology ecosystem excels at innovation, creation of an original product or service. China's technology ecosystem excels at imitating and improving on a successful business model. When a new approach proves successful, dozens or even hundreds of Chinese startups flood in and compete ferociously, exploring hundreds of variations. Few survive; the process rewards those best at iteration and execution.

Chinese legal, social, and interpersonal trust-based transactional norms remain poorly developed; mediating those experiences through objective digital decision-making platforms may significantly reduce transaction costs and enable new sorts of economic interactions that are taken for granted in the United States.

Meanwhile, China is now more open to accepting that, while market-exclusion and IP theft or copying helped it gain such a strong digital technology position, it should now protect the newer domestic innovations built on top of this foundation. Chinese firms seek to beat U.S. rivals in exporting these products to the developing world, especially Southeast Asia and Africa, extending Chinese influence in the process.

To take advantage of this perceived opportunity, the central Chinese government has provided signals to local officials encouraging them to support investments in artificial intelligence technologies, through "guiding funds," public projects, and performance evaluations. While some commentators have argued that the United States federal government should respond in kind with its own "AI strategy," it is important to keep in mind the fundamental differences and different tools available in China's "totalitarian market" economy and top-down governance system. Even in China, the most impactful applications of artificial intelligence today have largely come from private technology firms at arms-length from the central government and pursued for commercial ends. Kai-fu Lee observes that today the world's most valuable speech recognition companies, machine translation companies, drone companies, computer vision companies, and facial recognition companies, are all Chinese.

Alongside these advancements, many jobs throughout the Chinese economy are vulnerable to disruption.

One category is physical work. Nearly half of Chinese workers are on farms or in factories, often performing repetitive tasks which are subject to automation and robotization. Productivity of today's rural workers is particularly poor in China, especially in regions with small plots, lack of investment, and poor logistical infrastructure. Meanwhile, China is by some measures already the world's most competitive manufacturing power. It is also already the world's largest robotics market. But penetration levels remain below the global average, and firms have responded by attempting to acquire established overseas vendors and technologies. The pace of disruption felt in both fields will depend on how quickly capital-intensive automation or advanced-manufacturing practices can be successfully applied to these tasks.

Another category is white-collar jobs. Here the impact on employment is likely to be varied. Machine learning performs well under certain conditions—abundant data, narrow goals, and clear outcomes. But it struggles with strategic tasks, unclear goals, and creative or social tasks—all areas where many of today's white-collar employees are likely to have more job security. Many care, service, and creative jobs—at both the high and low ends of the economic spectrum—are likely to be secure. Many middle-income college-educated office workers, however, who take data and make predictions face risky prospects. The implications for this uneven impact across economic groups will be a challenge that China shares with other modern economies including the United States.

**Communication Technologies and the State-Citizen Relationship**

Maria Repnikova observes that "much of Chinese life is increasingly virtual," a transition which has not led to democratization of the country but which has created an "unprecedented space for public expression."

WeChat, for example, has over a billion active users. Individuals use WeChat to connect with each other, receive news, and make mobile payments for almost everything. Through platforms like WeChat or the Weibo microblogging social network, society can now access prominent journalists, lawyers, professors, and intellectuals. Civil society groups collaborate. Digital peer-to-peer financial technologies have gained rapid adoption in a society with a traditionally underdeveloped personal financial system.

News also breaks first on the internet. As Chinese citizens moved towards digital communications and social media platforms in the 2000s, traditional news outlets struggled in China as elsewhere globally. In China, this demise also meant the weakening of conventional propaganda. Authorities at times lose control of discussions that start online but sometimes move into real life as well.

This digital communications revolution created a new vibrancy in China, especially since the first movers to occupy

this technological whitespace have generally been private parties who otherwise faced great barriers to success and innovation in state-controlled media. And private Chinese citizens reap the benefits of that, despite using an internet which has been largely, and is increasingly, cut off from access to foreign content or participation by foreign firms.

Meanwhile, Chinese authorities are responding. Xi Jinping's administration has placed the "battle" for public opinion as a core party objective, adopting sophisticated government and party digital media "PR" strategies that seek to leverage these technologies to improve operational and responsive governance—"responsive authoritarianism"—while nonetheless attempting to strictly control any content that could lead to mobilization or action..

This has led to a complex relationship between authorities and individuals.

On the one hand, authorities use censorship and surveillance to support authoritarian rule: journalists and editors receive censorship instructions, censors weed out negative elements, and commentators—paid or voluntarily nationalistic—inject pro-regime views. As an explicit prerequisite for doing business, private Chinese internet companies furthermore funnel (compulsory) real-name user data by default to authorities, allowing them access to vast collections of citizen data. Firms use this to mine personal information and train algorithms for new products and services. Authorities use it to monitor the activities of individuals and to establish "social credit" systems to reward pro-regime behaviors and punish activities contrary to the regime's wishes. Most darkly, China's advanced digital surveillance capabilities have been put to use to turn entire provinces into near police-states in the name of public security: increasingly private intrusions have been piloted on the daily lives of the Uighur ethnic minority in Xinjiang Province, elements of which are then spread to the broader Chinese populace over time.

But authorities also use the internet to identify citizen concerns and solicit feedback—using these digital tools as a new way to boost legitimacy. The CCP has built an immense infrastructure of social media minders at all levels of government to manage and monitor its network platform-based interaction with the public. Official social media mix the party line with entertainment and advice. Censorship is intentionally incomplete and sporadic, allowing a publicly visible but nonetheless controlled venting of opinion. Individual expressions of discomfort, including about corruption, pollution, and inequality, are monitored to gauge public sentiment. This is all up to a point: authorities are most sensitive to discussions that could lead citizens to mobilize and take action. Uncontrolled cyber nationalism, especially among youth, is also regarded as potentially destabilizing when it ends up constraining authorities' decision space. Both Chinese citizens and officials are adaptive and innovative, resulting in a more politically active society and a more responsive authoritarian state.

Overall, authorities regard China's internet management strategy as a success given the threats these technologies looked to pose to the regime in the early 2000s. As with commercial technology firms "going out," authorities also aim to export scaled-down models of Chinese-type "cybersovereignty" to other interested developing nations. This suggests an increasingly divergent U.S.-China global model of internet governance, digital technologies, and society-state norms. Against this backdrop, some commentators suggested that U.S. tech firms should consider how engaging in the Chinese market may negatively affect their own global images. Others, however, pointed out that U.S. firms should resist shying away from developing country markets for values-based reasons only to cede that market to players without any western influence.

**Concluding Observations**

Ambassador Stapleton Roy observed that China is acutely aware of the heavy price it has paid throughout modern history for its technological backwardness. But today, Chinese authorities see an opportunity to level the playing field. In this round of history, both commercial and state actors are mobilizing to become masters of twenty-first century technologies, not just to neutralize this historical source of weakness but also to use these technologies as a way to leap over the significant challenges the country now faces. These capabilities are seen as a potentially novel path to overcoming the middle-income trap through continued rapid economic growth until mid-century, while sustaining Chinese-style authoritarianism.

One question is are Chinese-style central planning institutions capable of handling this complexity and uncertainty? It is important to understand, however, that while Beijing may set goals for technological achievement, the relatively small central government and party apparatus often relies on distributed, bottom-up regional efforts to implement them. Private tech firms develop advanced facial recognition capabilities because of a willing municipal public security bureau buyer—and guided by a compulsory board seat given to a party member. A local cadre gives free land to a local agricultural robotics manufacturer to cultivate a new source of tax revenue—and receives positive career

promotional consideration in doing so. A county environmental agency receives central government funding to hire a full-time social media monitor, using public opinion to prioritize enforcement efforts on the worst polluters—while censoring efforts to plan a citizens protest. Moreover, our panelists observed that Beijing's pragmatic streak means that midterm corrections can be made, often through quiet reorientation, when reality is not going to plan.

Despite this, some surprising retrenchment is visible today. For example, Beijing has returned to debt-based infrastructure spending to counteract economic growth slowdowns. It has fallen back on new rounds of subsidies to struggling state-owned enterprises rather than letting their more nimble domestic private sector competitors allocate capital. The urban-rural *hukou* identification system persists as too-attractive a tether on society to let go, despite the economic and potential humanitarian benefits to reform.

Moreover, China's economy is probably not as strong as it appears. A recent Brookings Institution paper by researchers at the University of Hong Kong and the University of Chicago estimated that China's annual economic growth rates from 2008 to 2016 had been overstated by as much as 1.7 percent each year and its investment and savings rates by even more. As the authors explain, China's central government calculates the country's economic performance using data from local officials, who are incentivized to exaggerate their own rates. Other analysts have pointed to economic implications of the country's extensive shadow banking and hidden debts. Such miscounting can add up over time, and it has actually led to the rise of cottage industries using new technology such as commercial satellite imagery and other proxies to arrive at more actionable estimates of Chinese economic activity. Whatever the true figures, this points to the importance of looking for Chinese strengths and weaknesses as they are, and not through a narrative of predetermination.

All told, China faces serious countervailing trends: technological dynamism and a novel model of agile governance weighed against demographic decline, authoritarian rule, and environmental challenges. As it seeks to escape the middle-income trap, will artificial intelligence and other advanced technologies spur sufficient productivity growth—and do so quickly enough—to counteract the loss of labor supply? Will they provide a great leap forward and make China a "modern well-off society," despite the commensurate social disruption risks, such as job losses, or rather play supportive, incremental roles as stepping stones? Chinese domestic perceptions of progress here are likely to affect geopolitical calculations as well: the timing of and priority placed on China's Taiwanese reunification aims and the hand-off between Deng Xiaoping's aphorism of "biding time" versus Xi Jinping's consciously outward-projecting "One Belt, One Road" for example. Overestimation of technological progress could lead to miscalculations of ambition and capability.

In particular, China's emerging means of governance through its use of these technologies—responsive authoritarianism—brings new wrinkles to the old image of a centralized state. Some commentators speculated that going forward the government may lean harder on these tools for tracking citizens' behavior and coercing or incentivizing behavior. Might this approach be extended to address China's demographic challenges, perhaps to encourage higher fertility, for example, by crediting those who have more than two children while punishing those with fewer?

Beyond its borders, China may seek to export this governance model (which it views as legitimacy-enhancing) to willing developing states as an alternative to the West's own export of liberal democracy. The spread of Chinese-style authoritarianism may therefore pose an ideological challenge for the United States and its traditional values of a free internet, free expression, privacy, and democratic governance.

China's technological prowess and progress challenge U.S. supremacy in this area as well. It may be tempting to try to hinder Chinese technological efforts in a bid to maintain superiority or in justifiable grievance for China's past failures to abide by international rules of trade or statesmanship. In the long-term, as we deal with China as both a strategic competitor and major trading partner, much will depend on how the United States addresses its own headwinds on these same matters of demography, technology, and governance over diversity.

For the United States, it is important that we do not try to "out-China" China. Rather, we should focus on bolstering our own strengths:

The United States government should continue to make the global case for liberal democratic values, which retain universal appeal if not universal applicability. It should also support the ability of the U.S. private sector and civil society to do the same through cultural and human outreach—this is an area in which the United States is an undisputed leader and China shows few prospects of catching up.

More concretely, U.S. values can be applied towards updating ideal models of internet governance and business too. In the early years of Web 2.0, U.S. digital firms decried then-nascent efforts by China to first censor and later close off its internet market. More recently, the United States focused on European efforts to fine, tax, and closely regulate U.S. internet businesses. As U.S. society now re-examines some its own attitudes towards domestic digital communications, it should do so with an eye towards ensuring both the competitiveness and attractiveness of U.S. internet business and governance models in developing countries, the next wave of global online marketplace growth. Becoming too inward-looking at this point in history could have long term implications for our ability to affect ideals and norms in this increasingly central realm of global influence and culture.

Similarly, as technological advances such as automation change the nature of work in this country, the United States should not forget that it remains part of the world, whether it likes it or not. Lessons learned, positive and negative, from the last three decades of trade liberalization can be applied to technological disruptions—we can do better from experience. The American government need not copy the Chinese state's AI development campaign, for example, but it should not stand in the way of productive technological development for fear of social impact. Our global competitors with no such compunction may instead end up being the ones doing the disrupting. At minimum, the United States should ensure that it has created the framework to enable private development of twenty-first century technologies: rule of law, strong infrastructure, minimizing costs of doing business, liquid markets, and a predictable regulatory framework.

Technological advances will also color the strategic competition between China and the United States. Chinese military planners see a future of warfare enabled by data and computational capacity and are pursuing a host of AI-enabled military capabilities—an effort made possible in part by substantial, if compulsory, civil-military fusion of technology companies. The full U.S. response to China's military expansion is a topic for another time, but, as in the realm of internet governance, the United States cannot emulate the Chinese approach here, nor should it. Instead, we must work to secure and sustain our superior technology, committing the resources and infrastructure necessary to expand and capitalize on research into the military applications of AI. At the same time, we must remain cognizant of the risks to strategic stability posed by AI-enabled early warning and command and control systems.

Finally, the environment. The United States is fortunate to possess a variety of excellent natural resources and to have had a century of experience in developing the complex institutions necessary to preserve human health and environmental quality while sustaining a robust industrial base. Chinese (and other) visitors to the United States routinely remark at how enough money can buy most material aspects of American life in modern cosmopolitan cities such as Shanghai or Beijing—but it cannot purchase clean air, water, and food. In China, over 1.5 million deaths each year have been attributed to air pollution, and drought pressures, already severe, are expected to grow. As the United States justifiably seeks to maintain global economic competitiveness while staring down potentially daunting new environmental and resource challenges such as climate change, it should play to its own ideals and be careful not to accidentally let go the things that make America great today.

**Notes**

## About

New and rapid societal and technological changes are complicating governance around the globe and challenging traditional thinking. Demographic changes and migration are having a profound effect as some populations age and shrink while other countries expand. The information and communications revolution is making governance much more difficult and heightening the impact of diversity. Emerging technologies, especially artificial intelligence and automation, are bringing about a new industrial revolution, disrupting workforces and increasing military capabilities of both states and non-state actors. And new means of production such as additive manufacturing and automation are changing how, where, and what we produce. These changes are coming quickly, faster than governments have historically been able to respond.

Led by Hoover Distinguished Fellow George P. Shultz, his Project on Governance in an Emerging New World aims to understand these changes and inform strategies that both address the challenges and take advantage of the opportunities afforded by these dramatic shifts.

The project features a series of papers and events addressing how these changes are affecting democratic processes, the economy, and national security of the United States, and how they are affecting countries and regions, including Russia, China, Europe, Africa, and Latin America. A set of essays by the participants accompanies each event and provides thoughtful analysis of the challenges and opportunities.



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