HEARING ON CHINA'S CHALLENGES AND CAPABILITIES IN EDUCATING AND TRAINING THE NEXT GENERATION WORKFORCE

HEARING

BEFORE THE

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

ONE HUNDRED EIGHTEENTH CONGRESS
FIRST SESSION

FRIDAY, FEBRUARY 24, 2023

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WASHINGTON: 2023

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REPORT PREPARED FOR THE COMMISSION

HEARING ON CHINA'S CHALLENGES AND CAPABILITIES IN EDUCATING AND TRAINING THE NEXT GENERATION WORKFORCE

FRIDAY, FEBRUARY 24, 2023

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

Washington, DC

The Commission met in Room 406 of Dirksen Senate Office Building, Washington, DC and via videoconference at 9:30 a.m., Commissioner Robin Cleveland and Commissioner Reva Price (Hearing Co-Chairs) presiding.

OPENING STATEMENT OF COMMISSIONER ROBIN CLEVELAND HEARING CO-CHAIR

COMMISSIONER CLEVELAND: Welcome to our hearing on education and training the next generation of work force in China. This is the commission's second hearing, and I have to say I'm more excited about this than probably any hearing I've been to. So, part of it is because of the many contradictions that, in reading the testimony, there are really strong competing points of view, which I think is helpful to our decision making.

Witnesses today, the staff has done a phenomenal job on preparing a statement, I commend it to everybody to read. When I finished reading the testimony last night, I decided there were some key points that I wanted to identify. Our witnesses today will testify and agree that education and training will determine whether China succeeds or fails in its ambitions, that education is the key overlook factor shaping the U.S. China competition.

Their recruiting efforts will impact the goal of technological independence and economic growth. Without education, there is no quantum computing, surveillance society, electric vehicles, cyber security, or military technology. All rely on the quality of graduates from Chinese schools.

What our witnesses don't agree upon is the state of education, so that's for us to assess today. There seems to be a series of contradictions. We see fantastic sums of money invested in so-called world class universities, and specialized higher education institutions. But we also hear about an innovation gap and a diffusion deficit.

We also know that China spends less of its GDP on education than Brazil and Mexico. We will hear about specialized training programs, and high-tech degrees, and yet we also know there are outdated textbooks with faculty that are so out of touch that they don't understand industry needs.

There has been a remarkable increase in access to universal education, and the number of graduates coming out of those schools has exponentially increased. Those graduates are making less than migrant workers if they get employed at all. And there is now widespread rumors of people quietly quitting because of disappointment in the job markets.

We've seen investment and priority attention on vocational education, but culturally, vocational education is viewed as a dead end and failure. AI and computer chips are the biggest priority in attention, and yet one of our witnesses identifies that there's a 5 million person shortfall in terms of hiring for '23, and 10 for 2024.

And with many companies complaining that the graduates from these schools do not have the skills necessary. And then finally we have the basic issue of an aging population, which will have a huge influence on the future of China's economy, and the competition. So, I guess the question I'm really consumed with today is are we overstating the threat that China represents as a security or economic juggernaut because they simply don't have an educated work force that they can rely on as they go forward in the future?

We asked for, and got a fantastic paper from Professor Hannum at the University of Pennsylvania, and that will be part of the record for today. I am delighted to have been joined in this effort by our new Commissioner Price, and I will turn it over to her to make her remarks, and then introduce the first panel. Thank you.

OPENING STATEMENT OF COMMISSIONER REVA PRICE
HEARING CO-CHAIR

COMMISSIONER PRICE: Good morning, and thank you Commissioner Cleveland, good morning to everyone. Today, China's efforts to directly influence, and potentially mediate, Russia's unprovoked war in Ukraine are making headlines. As China strives to exert greater influence over world affairs, it is crucial to understand the factors within the country that drive its behavior on the global stage.

Few topics will have more significant impact on the success or failure of China's evolving international ambitions than the subject of today's hearing, China's education system. The Chinese Communist Party aims to propel China to the forefront of global education by 2035. An aspiration that ranges from vocational training to graduate studies, and from research in science and technology to the social sciences and humanities. This hearing aims to investigate the ability of China's education system to equip the work force with the necessary knowledge and skills to meet those goals. Despite lofty ambitions, China is beset by challenges ranging from inequality, to a broad disconnect between the education system, and the labor market.

At the same time, other CCP priorities are creating tension with its educational ambitions. Under the leadership of General Secretary Xi Jinping, the Communist Party has tightened its grip on all aspects of society, including education in pursuit of regime security and political control.

Greater ideological and political control over China's universities threatens to undermine academic freedom and stifle innovation. Meanwhile, the crackdown on ethnic, and religious minorities in Xinjiang and Tibet raises serious concerns about the use of education as a tool for political, ethnic, and cultural oppression.

And over the past few years, the Chinese government has revised curriculum in schools in Hong Kong as part of a larger effort to quash descent. As the Party-state weighs competing demands with economic growth and political control in undertaking changes to its education system, there are important implications for the United States.

Whether China's education system meets the country's developmental needs will weigh heavily not only on China's economic growth and innovation, but on its ability to influence world affairs. In highlighting the limitations, ambitions, and tensions within China's education system, we hope this hearing will gain a better understanding of China's future trajectory.

I look forward to insights and perspectives from our panelists on these important issues. Before we begin, I would like to remind you all that the testimonies and transcripts from today's hearing will be posted on our website. Please also mark your calendars for the commission's upcoming hearing on China's global influence, interference, activities on March 23rd.

PREPARED STATEMENT OF COMMISSIONER REVA PRICE
HEARING CO-CHAIR

Hearing on "China's Challenges and Capabilities in Educating and Training the Next Generation Workforce"

February 24, 2023

Opening Statement of Commissioner Reva Price

Thank you, Commissioner Cleveland, and good morning everyone.

Today, China's efforts to directly influence and potentially mediate Russia's unprovoked war in Ukraine are making headlines. As China strives to exert greater influence over world affairs, it is crucial to understand the factors within the country that drive its behavior on the global stage. Few topics will have a more significant impact on the success or failure of China's evolving international ambitions than the subject of today's hearing: China's education system.

The Chinese Communist Party aims to propel China to the forefront of global education by 2035, an aspiration that ranges from vocational training to graduate studies, and from research in science and technology to the social sciences and humanities. This hearing aims to investigate the ability of China's education system to equip the workforce with the necessary knowledge and skills to meet those goals.

Despite lofty ambitions, China is beset by challenges, ranging from inequality to a broad disconnect between the education system and the labor market. At the same time, other CCP priorities are creating tension with its educational ambitions. Under the leadership of General Secretary Xi Jinping, the Communist Party has tightened its grip on all aspects of society, including education, in pursuit of regime security and political control. Greater ideological and political control over China's universities threatens to undermine academic freedom and stifle innovation. Meanwhile, the crackdown on ethnic and religious minorities in Xinjiang and Tibet raises serious concerns about the use of education as a tool for political, ethnic, and cultural oppression. And over the past few years the Chinese Government has revised curriculum in schools in Hong Kong as part of a larger effort to quash dissent.

As the Party-state weighs competing demands of economic growth and political control in undertaking changes to its education system, there are important implications for the United States. Whether China's education system meets the country's developmental needs will weigh heavily not only on China's economic growth and innovation, but on its ability to influence world affairs. In highlighting the limitations, ambitions, and tensions within China's education system, we hope this hearing will help us gain a better understanding of China's future trajectory. I look forward to insights and perspectives from our panelists on these important issues.

Before we begin, I would like to remind you all that the testimonies and transcript from today's hearing will be posted on our website. Please also mark your calendars for the Commission's upcoming hearing on "China's Global Influence and Interference Activities" on March 23rd.

We'll now begin today's hearing with our first panel.

PANEL I INTRODUCTION BY COMMISSIONER REVA PRICE

COMMISSIONER PRICE: We'll now begin today's hearing with our first panel. Our first panel will examine the interconnection between education and China's economic growth and development. We'll start with Dr. Scott Rozelle. Dr. Rozelle is the Helen F. Farnsworth Senior Fellow at the Freeman Spogli Institute for International Studies at Stanford University.

His testimony will discuss China's urban rural divide in education, and other major obstacles to future growth. Next we'll hear from Dr. Prashant Loyalka, who is also a senior fellow at Stanford's Freeman Spogli Institute. He will discuss the progress China's education system has made, and the challenges that remain.

Finally we'll hear from Dr. Zachary Howlett, assistant professor of anthropology at Yale-NUS College at the National University of Singapore. Dr. Howlett will analyze China's system of examinations, and their importance to regime stability and China's overall development. Thank you all very much for your testimony, the Commission is looking forward to your remarks.

I ask all witnesses to please keep their remarks to seven minutes. Dr. Rozelle, we'll begin with you.

OPENING STATEMENT OF SCOTT ROZELLE, HELEN F. FARNSWORTH SENIOR FELLOW, FREEMAN SPOGLI INSTITUTE FOR INTERNATIONAL STUDIES, STANFORD UNIVERSITY

DR. ROZELLE: Good morning Commissioners. I'm going to be talking about an area of China's education system that was very important, I think for economic growth, but that was barely mentioned in the opening remarks. But it's two thirds of China's education system. This is the education system that educates the rural part of the population. 60 to 70 percent of China's population is in this rural sector.

And there are many reasons why China's economic growth might stagnate or contract. Too much planning, unbalanced growth, aging population, etcetera. But I believe one of the biggest problems that few people know about that may undermine China's growth in the coming years can most simply be looking at the human capital of the entire labor force.

This is everyone from 16 to 65, it's about 800 million people. But I'm looking at the rural economy that makes up two thirds of that labor force. And I will show you China has one of the lowest educated labor forces in the entire middle-income world. So, what's a problem with the low educated labor force?

According to OECD, there's three types of economies that we're interested in. I call them the long-time wealthy nations, U.S., Japan, Denmark, etcetera. Then there's the graduates. Those are the countries in the last several decades that went from middle-income to high income. South Korea, Israel, Ireland, Singapore. And then there's the stuck in the middle-income trap countries. Turkey, Thailand, Mexico, South Africa. They were middle-income in 1960, they're middle-income today.

So, while there are a number of different factors that may account for this ability to go to high income and the stuck in the middle-income track, there's really one thing I think that's underappreciated that accounts for the disparate paths of these countries.

In wealthy countries, in the graduates, between 70 to 80 percent of this whole labor force have been to high school, or above. They're fluent in math and science, and computers, and more, and they're able to participate in the high skill jobs that are in high income economies, that are able to learn how to learn as these economies evolve.

Conversely, in the trapped countries, only between 30 to 40 percent of the labor force has ever been to high school, and they lack those skills. There's this under-educated population can't productively participate in the economy. It becomes a burden. They cause social problems, crime even, and is known to be part of the forces that lead these economies to stagnate, and even contract.

The ensuing vicious cycle has ensnared many of these middle economies for decades. So, how does China measure up? As I said above, China's education is one of the lowest in the middle-income. It is the lowest upper middle-income country in terms of this OECD definition of the share of the labor force that's been in high school. It's lower than Turkey, it's lower than Mexico, it's lower than South Africa.

This means 500 million people, only 30 percent, only 3 out of 10 people in China's labor force have ever been to one day of high school. And that means 500 million people, almost all poor, rural individuals have no skills that allow them to participate in the high-skill, high-wage economy. You need some people to be low skill in an economy, but you don't need 500 million if China would ever get to this high-income level.

In fact, even before COVID we begin to see problems emerge. There's a polarization of wages that are just starting now. Manufacturing and construction jobs are falling, people are being dumped into informal service sector.

Tens of millions of workers are there in this area where demand isn't high. Wage growth has been stalling, hours falling, unemployment rising, and in 2019, the last time I was in China, you were talking to these young rural people, they were beginning to worry about the future for the first time in the last 30 years. And there's even minor rumblings of discontent.

So, what's the source of the problem? I don't have time to get into this today, both Prashant and I talk about it in our formal written testimony, but the government's been worried about this, and they've been investing in this sector, but there's still not enough.

Teachers are low quality, teachers are unsatisfied. Many children have to board at school when they're six years old, and above. Parents aren't home, and they're separated for months, and there's still health and nutrition problems in this. But the biggest problem, the thing that my group has been working on for the last probably ten years, or so, is the high rates of cognitive delay among the rural population.

That's not genetic, or even nutrition. It's the lack of a quality home environment as these kids are young. Zero to three, three to six, they lack the stimulation, and support. A recent systematic review published in the British Medical Journal of Global Health found that almost 50 percent of three-year olds in rural China have either cognitive language or social emotional delay.

And science is clear, if your brain isn't developed in early childhood, you aren't going to do well in school. You aren't going to learn those skills that they need. So, unfortunately from China's point of view, the government has not started addressing this. It's shown that parental training programs to reduce this problem work. But even though other middle-income countries have really started to promote this part of government investment in human capital, China hasn't started yet. And I think that that is trouble for them in the future.

So, in summary, is China doomed to fall into this middle-income trap? If you look from this perspective, I think that they face lots and lots of challenges.

Of course, a nation's economy relies on more elements than the overall human capital, labor force. It's important, China's doing quite well in investment, into infrastructure, the health of the external economy, and it's possibly successes in these areas will offset there. But I think their other problems of over-investment, and unbalanced growth, there's a high chance that China could slide into this middle-income trap.

So, I'm going to end right there. Thank you Commissioners.

PREPARED STATEMENT OF SCOTT ROZELLE, HELEN F. FARNSWORTH SENIOR FELLOW, FREEMAN SPOGLI INSTITUTE FOR INTERNATIONAL STUDIES, STANFORD UNIVERSITY

Friday, February 24, 2023

Testimony before the U.S.-China Economic and Security Review Commission

Hearing on "*China's Challenges and Capabilities in Educating and Training the Next Generation Workforce*"

Scott Rozelle
Senior Fellow, Freeman Spogli Institute for International Studies, Stanford University

China's economy has grown rapidly over the past 40 years; today it is the second largest in the world (Morrison 2019). Recent research (Gustafsson et al. 2020) has shown that in recent decades nearly 400 million of China's people have moved into the global middle class. China today is classified as an upper middle-income country. While many observers have assumed that China's continued growth and transition into a high income/high skill economy is a given, Figure 1 shows two things. First, as of 2015 China still has a significant way to go to become a high-income country. Second (and the subject of this testimony), I believe that by looking at the human capital of China's current labor force (especially that part of the labor force that is from China's rural areas—still accounting for more than 60% of the population in terms of residency permit status) that there are serious questions about whether this transition out of middle income can proceed smoothly. Although China has focused a great deal of attention in the past decade-plus on the rural population in terms of education (i.e., the government has invested a lot and made some positive changes), there are still hundreds of millions of poorly educated individuals in the labor force that do not have the skills to contribute to a high income/high skill economy; China's education system also is still in need of additional massive investments and fundamental reforms, starting even when children are infants and toddlers.

The middle-income graduates and the trapped

According to the OECD (2016), there are three types of economies that exist in the world today. The first set of nations is comprised of countries that were high income in 1960 and are still high income today, such as the United States, Denmark, Japan and other OECD countries. The second group is made up of a small group of nations that have moved up from middle income (in the 1960s) to high income status today, like Ireland, Israel, South Korea, and Singapore. The third grouping are those nations that are "stuck in the middle-income trap." These are countries, including Turkey, Thailand, Argentina, Brazil, Mexico and South Africa, that were middle income in 1960 and are still middle income today. Decade after decade, the members of this group have endured false starts and cycles of growth followed by contraction or collapse without ever managing to rise to high income status. When contraction or stagnation in these countries occurs, millions of people often are hurt and the livelihoods of families invariably fall.

While there are a number of different factors that may account for the difficulty of escaping from the middle-income trap, one underappreciated factor that may account for the disparate paths of these three groups of countries is education. Among wealthy countries, the average

share of the labor force (all individuals between the ages of 18 and 65) with at least a high school education is 78% (Rozelle et al. 2020). Countries that have exited out of the middle-income status to join the ranks of the wealthy also had high levels of at least high school education even when they were still middle income (72%). Conversely, in countries that have failed to exit from middle-income status, the share is much lower–only 36% of the labor force has a high school education, on average.

Education and economic upgrading

Why is it that the relatively low levels of human capital might be a key factor in keeping countries from transitioning from middle-income to high-income? In short, higher levels of secondary school education for its labor force are crucial for a country to make the transition to high income status. An educated labor force can more easily shift into higher value-added (or "white collar") jobs, facilitating the national transition from a low skill, low wage economy to a high skill, high wage economy. A good example can be found in the experience of South Korea. After wages in that country rose steadily in the 1980s, firms began to globalize and automate to replace increasingly expensive workers. This caused demand for low skill, labor-intensive employment to fall sharply (Li et al. 2017). However, because education rates were already relatively high at this time, displaced workers were able to shift into higher skilled work, for example, becoming accountants, clerks and office staff (Kim et al. 2016). In essence, more schooling allowed these workers to "learn how to learn," helping them reskill after leaving jobs on the factory floors or construction sites for new and higher paying employment (Khor et al. 2016).

As workers rise up the value chain their wages stay relatively high, as does their demand for services (Gustafsson et al. 2020; Kharas and Kohli 2011). High wage jobs with benefits encourage demand for high value services, creating a virtuous cycle that can sustain growth over the long term (Diacon and Maha 2015). By contrast, without sufficient education, too many unskilled workers are squeezed out of upgraded industries because they lack the skills to compete. Their wages can stagnate, curtailing demand and hampering growth, leading to serious social problems like crime, higher rates of unemployment, and social unrest. When unemployment and crime and social unrest rise, investors shift elsewhere, exacerbating the problem. The ensuing vicious cycle has ensnared many middle-income economies for decades.

So how does China measure up? In fact, China's overall education rate is one of the lowest in the middle-income world, according to the OECD metric on high school attainment. When one looks at Figure 2, one can see that comparing China's human capital with that of other countries, it is not only systemically lower than that in South Korea, Ireland, and other "graduates" out of middle-income status (Bai et al 2019; Li et al. 2017), the share of undereducated workers in China's labor force is larger than that of virtually all trapped middle income countries. According to China's own census data (in 2015), just 30% of the labor force between the ages of 18 and 65 had ever attended high school, which is less than the average of other middle-income countries (36%) and well below the OECD average (78%). Furthermore, China's census shows that, in 2010, only 12.5% of the overall labor force was college educated,

lower than that of most other middle-income countries (Li et al. 2017; NBSC 2010). In other words, China's workers (mostly those from rural areas) lag behind not only the graduates in terms of secondary and tertiary education levels, but also that of their middle-income peers.

Locked out of the middle class

China's middle class has grown at a rapid pace in recent decades, but an examination of its composition further highlights the risks of stagnation due to the existence of a huge low-income class (more than 900 million—Gustafsson et al. 2020). It is also true that the rise in the middle class has been tremendous, from nearly zero in the 1990s to around 400 million people in China today who can be said to be living at middle-income levels comparable to those in OECD countries (Gustafsson et al. 2020). But there has been an important common denominator in the growth of those that reach middle-income: almost all entrants into the middle class over the past 20 years have been urban people with formal, salaried employment. More than three-fourths of the middle class hold an urban residence permit (or hukou). Only 12 percent of the middle class consists of rural-to-urban migrants, while rural people that have not moved to big cities account for only 9 percent of China's middle class.

What is it about rural status that so curtails entry into the middle class? Systemic shortfalls in human capital formation have rendered them unable to compete with urban peers. Only 10 percent of rural students from rural areas in Central and Western China (the largest part of the rural population) pass the college entrance exam and enter college (Li et al., 2017). The numbers for high school are similarly troubling: In 2015, according to census data, only 11.3 percent of rural adult workers in the 25–64 age bracket had attained at least high school education. Enrollment quotas in high school and college make performance on standardized tests a key gateway to higher schooling, and rural students pass at much lower rates than urban peers. As early as primary school, children from rural areas are more likely to suffer from learning impairments, with nearly 60 percent of China's elementary school children (ages 6 to 12) having at least one health or nutrition problem (Zhou et al. 2015). Education spending in rural areas is much lower on a per capita basis than in urban schools, with implications for many aspects of rural education, from school infrastructure to teacher quality (Wei 2016).

What is China doing about this?

Does China realize that people in rural areas are falling systematically behind? In fact, there is evidence that China recognizes the problem and has been making substantial efforts to address some of the problems described above. Among the most obvious efforts over the past 15 years has been the expansion of secondary school enrollment, mostly in rural areas. Between 2005 and 2015, the overall high school attainment rate increased sharply, from about 1 in 2 children to about 8 in 10 (Bai et al, 2019). The rise has been most pronounced in rural areas, where in 2005 only 43 percent of children attended high school. Today the rate exceeds 70 percent. In cities today, well over 90 percent of children with an urban residence permit attend high school. Taken together, over the past 15 years China has put tens of millions more children into high school—a remarkable feat.

While the quantitative expansion of high school enrollment is impressive (and needed), quality problems have emerged. Much of the expansion, for example, has been in vocational schools. In the 2010s China's leadership bet that a big fraction of new high schoolers in rural areas would benefit more from technical rather than general education and expanded vocational high school rather than academic high school. Other middle-income countries have pursued this path, including Brazil, Romania, and Indonesia, for example (Newhouse and Suryadarma 2011; National Congress of Brazil 2011; China State Council 2010). Unfortunately, there is little evidence that these investments in vocational schooling have paid off. Cross-national studies using international standardized tests show that students in vocational high school vastly underperform their peers from academic high schools in terms of skills formation (Altinok 2011). China is no exception: studies have shown that vocational schooling has failed to instill either general learning or even specific vocational skills, and even induces drop out (Loyalka et al 2015). The promotion of vocational schooling, at least in its current form, as a substitute for academic high school, does not appear to be providing the boost in human capital that will help China's rural students compete. That is not to say that China's vocation high school program cannot be improved. However, to do so, there needs to be both more intensive investment into quality-improving aspects of the system, such as better teaching resources and a shift in focus to teaching basic skills—math, science, language, English and computers—rather than specific/narrow job skills that in many cases will become outdated in the near future.

So why are children not ready to attend academic high school? Is it a problem of the quality of schools (at the elementary and middle school levels)? Or do children have health and nutrition problems that reduce learning? In fact, if one looked at children in rural elementary schools a decade or so ago (between 2010 and 2015), there were many problems with both schools and the children themselves. The quality of schools used to be very poor, with old buildings, faulty lighting, insufficient desks, books and other materials. Many teachers were not being paid (or were being underpaid) and sometimes just stopped coming to class (Rozelle and Hell, 2021). Even when there were better classrooms, teachers and books, research showed that children were anemic; had intestinal worms; and were myopic, but, had no glasses.

But, while these problems still exist, most of these things are improving. In fact, China has invested enormously into improving school infrastructure; teachers are now paid by the central government on a timely basis; most schools have computer rooms and libraries and good quality equipment for teaching. A US$5 billion per year national, free, nutritious lunch program serves more than 25 million children per day in rural schools. Today, anemia rates are at levels that compare to developed countries (Wang and Zhang, 2023). Many provinces are promoting the use of eyeglasses to overcome the high rates of myopia in rural schools. And health programs provide families with access to deworming care in nearly all counties. Clearly schools have improved physically and children are healthier and more nourished than they were 10 years ago (Rozelle and Hell, 2021).

But, China is NOT through with its human capital challenge for rural individuals. Over the past several years, researchers have identified an even deeper problem among rural youth that no

amount of school expansion will address: cognitive skills that have failed to emerge in early childhood (Emmers et al., 2021). Almost 3 of 4 infants in China are growing up in rural villages and migrant communities. A review of research on infant development in China revealed that as many as 45 percent of rural babies were at risk for cognitive delays, slightly more than the rate in other middle-income countries (the rate in high income countries is closer to 15 percent). Low cognition in the first three years of life has been shown to lead to low schooling, employment, income, and health outcomes later in life (Heckman, 2006). The problem is not one of poor genes. Nutrition for infants and toddlers could be better, but, by 18 months old, nutrition is fine for most rural young children. The main problem is rooted in insufficient stimulation of infants from caregivers. Studies in China show that close to half of rural caregivers rarely read, sing, or talk to their babies, either because they are out of the village working (as a migrant and have left their children behind with grandparents) or do not realize how important such engagement is (Emmers et al., 2021). While other middle-income countries, such as Brazil and Columbia and Peru and Mexico, have launched sweeping initiatives in recent years to address cognitive delay among infants through parental training programs, the issue has yet to find substantive traction among policymakers in China. No amount school expansion will compensate for poor outcomes in the critical first years of life.

So it seems as if there are no easy answers to the problem of China's massive rural labor force and their families of nearly 800 million individuals, a population that encompasses 1 in 9 humans. Even with the great effort of the government in recent years, education, health, productivity, and employment outcomes for this group are lower than people realize, and measures to address the problem are complex, expensive, politically fraught, and their pay off will not be felt for years. In the meantime, no analysis of China's growth prospects is complete without considering this rural human capital problem and the degree of success China has in mitigating it. To meet the challenges of simultaneously raising social benefits and adult retraining for rural adults as well as education, health and early childhood education for rural children will require a fundamental shift in priorities and massive transfer of resources.

Is China Doomed to Fall Into the Middle Income Trap?

I am a development economist and work on rural China. I am only an observer of China's macro policies and growth, so these comments must be "taken with a grain of salt."

On the one hand, there has never been a nation in past decades that has moved from middle income to high income (and stayed at high income) when their labor force has had such low levels of human capital. The three countries that were relatively low in terms of human capital in the 1970s and 1980s (around 50% of their labor forces had been to high school at that time) and were able to move from middle income to high income were Portugal, Spain and Greece. Of course, these countries had a tremendous amount of support from the EU after they joined and this invariably aided their transition to high income. Mexico, where only less than 40% of the labor force had been to high school, was admitted to the OECD in the 1990s as a high-income economy (they had just attained high income status in the early 1990s). Since the mid-1990s, however, the growth of Mexico has been near zero and they are currently classified as a

middle-income country again. Therefore, from the perspective of the level of human capital of China's labor force, it would seem that China is facing an uphill battle. China's informal economy is large and growing; wage polarization has been documented to be beginning; and it is unclear what 100s of millions of low educated workers could do in a high skill/high wage economy (and if China would be able to manage the social and economic unrest that might emerge if a large share of these became un- or under-employed).

Of course, a nation's economy relies on many more elements than the labor force's overall human capital. In other dimensions, China is doing quite well: investment into infrastructure; health of the external economy (including last year when US-China trade reached its highest point ever); absolute number of engineers; creation and adoption of technologies in many (but of course not all) fields. It is possible that successes in other areas could offset the negative effects of a labor force with a poor level of human capital (and the other impacts that this could have an economy).

Finally, economists that have predicted the downfall of China's economy in the past (at least 40 years) have invariably been wrong. I have been an economist studying China since the 1980s. During the past 40 years, economists have predicted major slowdowns or stagnations or collapses of the economy due to inflation and Tiananmen unrest in the 1980s; the reform of State-Owned Enterprises and the Asian Financial Crisis in the 1990s; WTO competition and the 2008 world recession in the 2000s. As seen from China's growth rates between 1980 and the early 2010s, none of the predictions were realized. China grew at an average of nearly 10 percent per year for almost 35 years in a row. It is true that growth has been slowing, but, it is possible that predictions that China is destined to stagnate or fall into negative growth (due to poor levels of human capital or anything else) may likewise not be realized.

One final word. We need to continue to monitor what is happening to the labor force in China. It is likely to put a lot of pressure on China's economy in the next 5 to 10 to 15 years. But, we also need to be prepared that China will find a way to keep growing. There are many positives and negatives to either a fall-into-the-middle-income-trap or a continued-growth-scenario. Understanding as much as we can about China's economy – in many dimensions – is an absolute MUST.

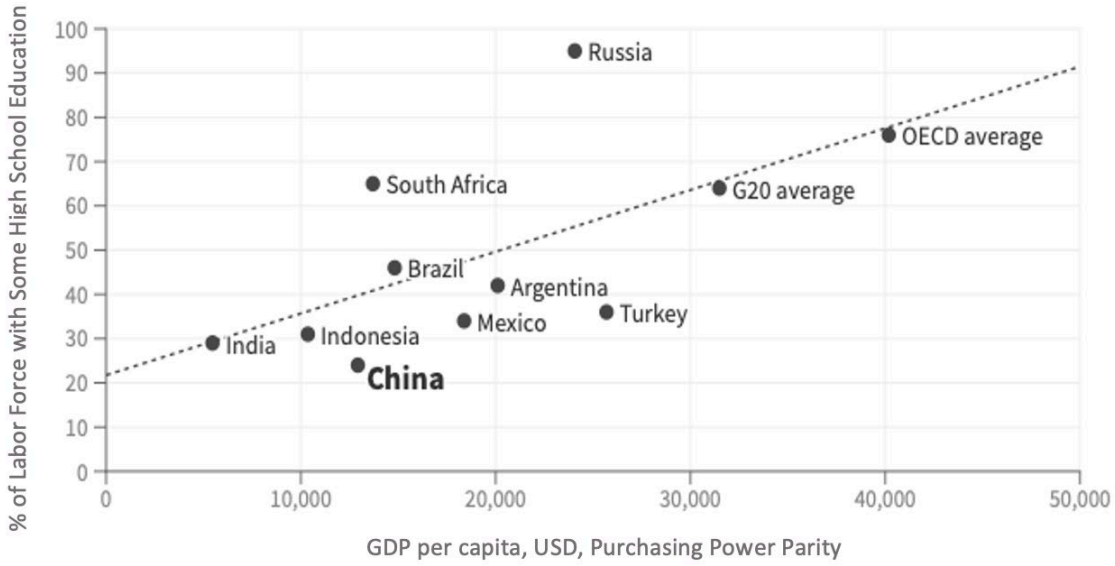

Figure 1. Relationship between GDP per Capita and Education in 2015

Source: IMF; Bai et al., "Past Successes and Future Challenges in Rural China's Human Capital;" OECD; National Bureau of Statistics of China.

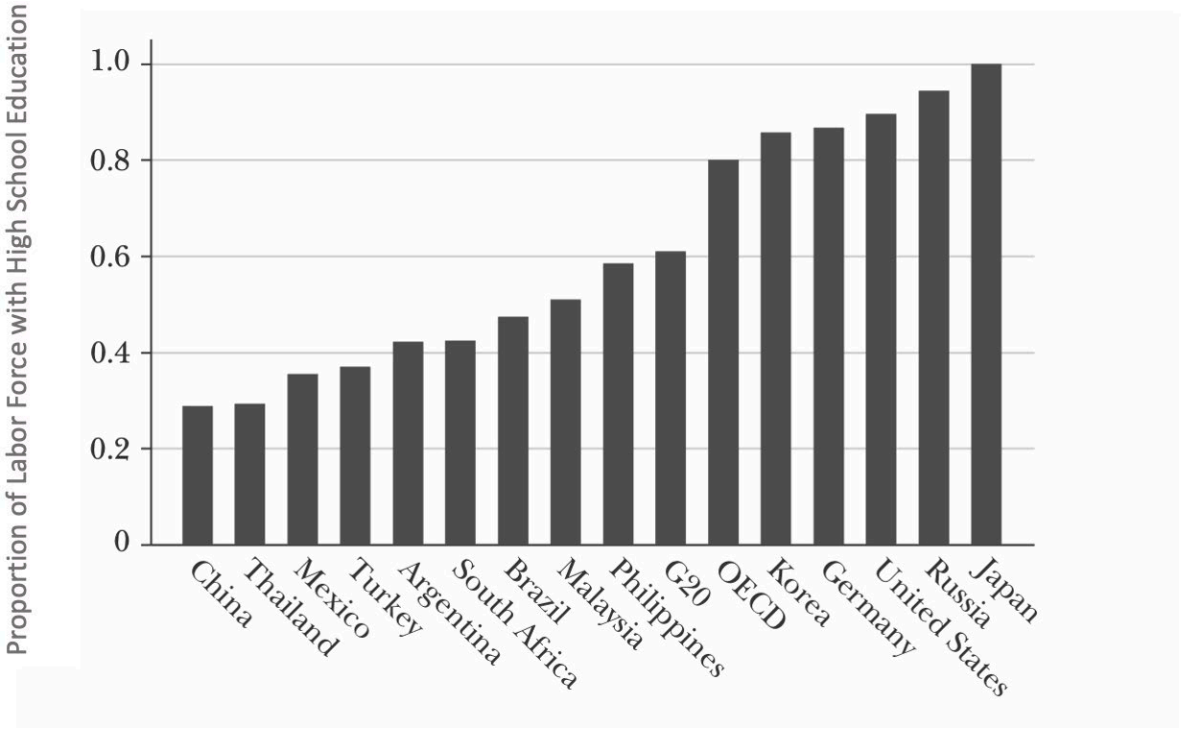

Figure 2. Proportion of the Labor Force Having High School Education in 2015

Source: Li et al. 2019. Journal of Economic Perspectives

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Figure 2: Hongbin Li, Prashant Loyalka, Scott Rozelle, and Binzhen Wu, "Human Capital and China’s Future Growth," Journal of Economic Perspectives 31, no. 1 (2017): 25–48,
The numbers for China are from Population Census 1982, 1990, 2000, and 2010 and the 1 percent population sample survey in 1995 and 2005. The numbers for other countries are from “Education at a Glance” by OECD, 2016, and UNESCO Institute of Statistics (UIS). The numbers for Malaysia, Thailand, and the Philippines refer to the proportion among the population above age 25, coming from UIS. The numbers in 2015 are not available for the following countries, and we use their information available in the latest year prior to 2010: Argentina (2003), Brazil (2014), Indonesia (2013), Malaysia (2010), the Philippines (2013), Russia (2013), South Africa (2014), and Thailand (2013).

OPENING STATEMENT OF PRASHANT LOYALKA, SENIOR FELLOW, FREEMAN SPOGLI INSTITUTE FOR INTERNATIONAL STUDIES, STANFORD UNIVERSITY

COMMISSIONER PRICE: Thank you very much. And Dr. Loyalka?

DR. LOYALKA: Dear Commission members, thank you so much for inviting me here today. Today I'd like to speak about China's education system and the progress that it's making. As you know, China has experienced rapid economic growth over the last four decades. This rapid growth is due in part both to the size of China's labor force as a proportion of the size of its population, as well as to improvements in labor productivity from rural to urban migration and privatization.

However, as China's population continues to age, urban migration peaks, and opportunities for privatization plateau, improvements in labor productivity rely increasingly on improvements in education.

Today, China's education system is one of the largest and most complex in the world. To better understand its role in developing human capital throughout the country, it's helpful to look at its system of education in rural and urban areas separately. It's also helpful to examine China's regular K-12 education system separately from its systems of vocational education and higher education.

In K-12 education, urban students have ample opportunities to receive a high-quality education. According to the international PISA test, 15-year-old students in economically-advanced provinces of China rank first internationally in reading, math, and science. A substantial proportion of urban students in less advanced provinces likely also have high levels of achievement.

As China has 61 million urban students in grades one through nine alone, clearly the country has a large pool of educated talent to draw on. It is important to note however, as Scott mentioned, that rural students still comprise about three fifths of students in the country.

Ensuring that the population of rural students receives education of sufficient quality remains a major issue in thinking about China's continued growth and increasing economic inequality. The issue of educating rural students is complicated by the household registration system, as well as the fact that rural students have to compete with urban students on competitive entrance exams to enter high school and college.

According to a nationally representative survey in 2018, there is a moderate-sized gap in achievement between rural and urban students. At the same time rural students in grades one through nine appear to be making steady achievement gains in school. This indicates that the quality of primary schooling, and junior high schooling in rural China is relatively high, at least compared to other developing country contexts. China can thus draw on a reasonably large pool of educated talent in rural areas as well.

That being said, while the vast majority of urban children eventually enter academic high school, which is a gateway to college, a much smaller proportion of rural students do the same. Rural students in fact frequently end up in vocational high school, or drop out of education all together.

The quality of vocational high in China is poor and not a major contributor to human capital development in the country. By contrast, students entering academic high school take rigorous and demanding college preparatory courses. Because of the rigor of the curriculum, competition to do well on the college entrance exam, and prior investments in schooling, the achievement levels of students at the end of academic high school are quite high. Across a

national study of students entering the four-year computing and engineering programs in China for example, shows that students in China are years ahead of students in India, Russia, and probably the United States in math and science achievement.

While students enter college with high levels of achievement however, during college they appear to learn very little in terms of basic academic skills and higher order thinking skills, like critical thinking. Cross national studies confirm that students in China's four-year public universities make few, if any, gains in math skills, and in fact lose science skills in the first two years.

Furthermore, by the end of four years, graduates in China have comparable levels of major specific skills, and critical thinking skills as graduates in India, and Russia, and considerably lower major specific skills, and critical thinking skills than graduates in the United States.

The lack of learning in these four-year public universities, which are the top one- and two-tier universities in the country implies that the quality of education is perhaps even worse in less resourced and less well-managed lower-tier colleges.

Let's go back to thinking about sheer numbers of students again. Over the last two decades, China has rapidly increased access to higher education. The proportion of 18 to 24-year-olds going to regular four-year undergraduate programs in China is now 16 percent, compared to 31 percent in the United States. At the same time, it's important to keep in mind that approximately 19 million students are enrolled in these programs in China, compared to 11 million in the United States.

In other words, China has a much larger pool of graduates in college than the United States, which has implications for the country's ability to modernize and innovate.

There have been no high-quality studies that I know of that look at the quality of graduate schooling in China. Sufficive to say that China also produces a very large number of graduate students. In the last ten years, it produced about 6.5 million master's degree students and 600,000 doctoral degree students. Policymakers in China have also been getting considerable attention in the last few years to improving the quality of graduate education. Whether graduate education is currently producing high quality students is doubtful considering the low quality of the undergraduate experience. However, it's quite possible that the quality of higher education, both at the graduate, and undergraduate levels can improve quickly if China invests the requisite resources, and effort.

In summary, China has a vigorous education system that is improving in size, accessibility, and quality. The country still faces considerable challenges, however, in addressing rural urban gaps in education, gaps that become increasingly manifest after junior high and which have implications for economic growth, inequality, and social stability. China also has a lot of work to do to improve its vocational and higher education systems. Given its strategic importance for national development, it seems highly likely that China will put considerable effort into improving its higher education system in the years to come. Thank you.

PREPARED STATEMENT OF PRASHANT LOYALKA, SENIOR FELLOW, FREEMAN SPOGLI INSTITUTE FOR INTERNATIONAL STUDIES, STANFORD UNIVERSITY

Friday, February 24, 2023

Testimony before the U.S.-China Economic and Security Review Commission

Hearing on "*China's Challenges and Capabilities in Educating and Training the Next Generation Workforce*"

Prashant Loyalka
Senior Fellow, Freeman Spogli Institute for International Studies, Stanford University

Education plays an important role in China's continued economic modernization. Prior to the pandemic, China sustained an incredibly fast rate of economic growth for four decades–an average annual gain in GDP per capita of close to 9 percent. Rapid growth was due in part both to the size of China's working-age labor force as a proportion of the size of its population as well as to improvements in labor productivity. Improvements in labor productivity were in turn due both to the reallocation of labor to more efficient sectors (rural to urban migration and the increased role of privatization in the economy) and to improvements in human capital (education and on-the-job-training). Because the size of its working-age labor force as a proportion of the population has decreased considerably and because the country has already reallocated much of its labor force efficiently (rural to urban migration has plateaued with the vast majority of able-bodied, working-age rural persons already working in urban areas; China now has a substantial private sector and state-owned enterprises have adopted many of the labor practices of private firms), further improvements in labor productivity will depend to a large extent on continued improvements in human capital. Therefore, education will play an even more important role than it has in the past in China's continued economic modernization.

Today, China's education system is one of the largest and most complex in the world.[1] To better understand its role in developing human capital throughout the country, it is helpful to look at education in urban and rural areas separately. It is also helpful to separately examine China's regular K-12 education system as well as its systems of vocational education and higher education.

In K-12 schooling, urban students have more opportunities and achieve better educational outcomes than rural students. In particular, students in China's urban areas appear to have high levels of language, math, and science achievement by the end of K-12 schooling. For example, according to the 2018 and 2015 Programme for International Student Assessment (PISA) fifteen-year-old urban residents in economically advanced provinces (Beijing, Shanghai, Guangdong, Zhejiang and Jiangsu together) scored higher than students from any of the other 70-plus participating countries in reading, mathematics, and science.[2] A large proportion of urban students in these economically advanced provinces also performed at the highest levels of proficiency in at least one subject in the PISA exams, indicating that these students had acquired

[1] According to the Ministry of Education of China, in 2021, China had approximately 108 million students in primary school (grades 1-6), 50 million students in junior high school (grades 7-9), and 39 million students in senior high school (grades 10-12).[1] China also had 48 million students enrolled in some form of early childhood education (including public and private kindergartens and nursery classes for ages 0-5).
[2] The United States ranked 8th, 30th, and 11th in reading, mathematics, and science in the PISA 2018.

knowledge, skills, and abilities to perform tasks of substantial complexity. While there is less representative evidence about the performance of urban students in less economically advanced provinces in China and there is undoubtedly substantial variation in achievement among urban students across China, a substantial proportion of urban students in these provinces also have high levels of achievement.[3] This plus the large number of urban students in China (61 million urban students alone in primary school and junior high school, i.e. grades 1-9, in 2020) implies that the country has a large pool of educated talent in urban areas alone.

Turning to K-12 education in rural areas, it is important to note that rural students still comprise the majority of students (61%) in the country.[4] Ensuring that the population of rural students receives education of sufficient quality thus remains a major issue in thinking about China's continued economic growth as well as its future economic equality and social mobility. The issue of educating rural students is complicated by the household registration (*hukou*) system in China, which often allocates opportunities to attend higher-resourced schools on the basis of household residential status.[5] The issue of educating rural students is also complicated by the fact that they have to compete for opportunities to attend higher levels and more elite categories of schooling with more resourced urban students that often perform better on competitive high school and college entrance exams.

Researchers have assumed but seldom documented that there is a substantial gap in math and language achievement between rural and urban students in K-12 education. According to somewhat crude measures of math and language achievement used in a nationally representative household survey in 2018, there is indeed a moderate-size gap in math and language between rural and urban students.[6] At the same time, there is evidence that students in rural primary and junior high schools appear to be making steady achievement gains in school.[7] This indicates that the quality of primary and junior high school in rural China is relatively high compared with other developing countries where achievement gains are low or negligible.[8]

The rural-urban gap in achievement does not appear to be due to gaps in government financing for rural versus urban education. Per student expenditures for primary and junior high

[3] For example, Loyalka et al. (2019) assess the math and science achievement levels of a nationally representative sample of entering college students selectively admitted into computing and electrical engineering majors in China (a large proportion of which are urban students from a range of provinces) and find that their achievement levels are very high - much higher than their counterparts in India and Russia.

[4] The number of primary and junior high school students (grades 1-9) in China in 2020 was approximately 156 million and 95 million of these students were from rural areas. Source: Ministry of Education in China. China's Education Situation in 2020.

[5] For example, only children with a *hukou* in a specific district are entitled to go to a public school in that district. The quality of schooling children receive therefore depends on whether on their (urban or rural) *hukou* status.

[6] The gap was 0.44 standard deviations in math and 0.32 standard deviations in language (based on an analysis of the China Family Panel Survey data from 2018 as detailed in a research paper written by Dr. Yue Ma at the Stanford Center for China's Economy and Institutions and his co-authors). Researchers unfortunately do not have access to enough data to interpret how large the achievement gap is in terms of number of years-of-education or some other easily interpretable measure.

[7] For example, one unpublished study describes administering vertically scaled math tests to thousands of rural students in less developed counties of Henan, Shaanxi, and Gansu provinces as they were progressing through junior high school. Importantly, students made steady gains in math achievement, regardless of their family's economic background and regardless of whether they were low or high achieving students.

[8] World Bank. (2017). *World development report 2018: Learning to realize education's promise*. The World Bank.

school do not appear to differ substantially between rural and urban areas. As of 2020, expenditures per rural student were $3,147 for primary school, and $4,245 for junior high school.[9] This is comparable to the national average of $3,370 for primary school and $4,870 for junior high school.[10] Moreover, policymakers substantially increased expenditure per student in rural areas from 2020 to 2021 (an increase of 10% for primary school and 16% for junior high school).[11]

The above figures for expenditures per student do not include parental investments in education which differ considerably for rural and urban households. To give some sense of these differences, in 2017, urban households spent approximately three times more on their primary school children's education than did rural households ($2,049 compared to $659).[12] This does not include investments in early childhood or investments of parental time which are also likely considerable larger in urban areas compared to rural areas. Gaps in parent's financial investments, which had been growing over time, may have diminished somewhat after a national policy to regular private tutoring in July 2021. Due to the competitiveness of the country's entrance exam system, however, it may be that the policy did not really work to diminish gaps in parental investment.[13] Rather, inequalities in household investments into education as well as related inequalities in educational opportunities and outcomes between rural and urban students in K-12 schooling will likely to persist far into the future.

After rural and urban students finish compulsory schooling (grade 9, the last year of junior high school), they can choose to take a high school entrance exam. Performance on the high school entrance exam largely determines whether students are tracked into academic high school or not. Students are eager to get into academic high school as most of academic high school students end up taking the college entrance exam and going to college. The vast majority of urban children enter academic high school while only some rural students do.[14] Rural students, in fact, frequently end up in vocational high school or drop out of the educational pipeline altogether.

In prior years, to provide rural students with greater opportunities for a high school education and labor market prospects beyond those associated with going to academic high school and college, policymakers had invested substantially in vocational high schools. Around 2010, for example, policymakers mandated a 50:50 split in academic and vocational high school enrollments. They also made vocational high school free for rural students and invested in special "model" or elite vocational high schools that would be of higher quality. Expenditures

[9] All expenditure amounts in the report are in US PPP-adjusted dollars. Source: China Education Expenditure Statistical Yearbook, 2021

[10] The national average includes both rural and urban students—official data are unavailable for urban students alone.

[11] For the sake of comparison, US still spends much more per student than China – approximately three times as much at $14,000 per student. https://nces.ed.gov/programs/coe/indicator/cmd/education-expenditures-by-country

[12] China Education Finance Household Survey, 2017.

[13] https://www.scmp.com/tech/policy/article/3186924/year-after-chinas-private-tutoring-crackdown-classes-have-moved

[14] Loyalka, P., Chu, J., Wei, J., Johnson, N., & Reniker, J. (2017). Inequalities in the pathway to college in China: when do students from poor areas fall behind?. *The China Quarterly*, *229*, 172-194.

per student in academic and vocational high school were also comparable.[15] Despite these efforts, the quality of vocational high school education was extremely poor. Students learned few vocational skills and few if any academic skills. Dropout rates were high and morale among students and teachers was low. Likely due to the poor quality of vocational schooling as well as parallel efforts of the government to expand academic high school and college slots, the percentage of students attending academic high school increased markedly by 2021 to 66.5% (~26 million students), while the percentage of students attending vocational high school decreased to 34.5% (~13 million students). Vocational high schooling is therefore not a major contributor to human capital development in China today.

As previously mentioned, in contrast to students in vocational high school, students in academic high school have a high probability of entering college after three years. In preparation for the competitive college entrance exam, they take rigorous and demanding college-preparatory courses in math, biology, chemistry, physics, literature, English, and other subjects. Because of the rigor of the curriculum, competition to do well on the college entrance exam, and prior years of investments in schooling, the language, math, and science achievement levels of students at the end of academic high school are quite high. For example, a cross-national study of nationally representative samples of students entering four-year computing and engineering programs in China, India, and Russia (with some baseline comparisons with the United States) showed that students in China were years ahead of their counterparts in other countries in math and science achievement.[16,17]

Having provided background about China's K-12 education system, including its vocational high schools, I would like to now discuss China's higher education system. China's higher education system expanded very rapidly since the late 1990s. That, combined with its decreasing population of college-going youth, means that a higher proportion of college-eligible youth are now being admitted into college. The proportion of 18-24 year olds going to either regular undergraduate programs (typically four-year programs) or vocational higher education programs (typically 2 or 3 year programs) is now approximately 28.5% compared to 40% in the United States. The proportion of 18-24 year olds going to regular four-year undergraduate programs is 16% in China compared to 31% in the United States. Even though the gross enrollment rate for regular undergraduate programs is almost twice as large in the United States, it is important to keep in mind that approximately 19 million students are enrolled in these programs in China compared to approximately 11 million in the United States.[18] In other words, China has a much larger pool of college educated youth than the United States, which has implications for its ability to modernize and innovate.

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[15] Even in 2021, academic high school expenditure per student was $4,492, while vocational high school expenditure per student was $4,083. Source: China Education Expenditure Statistical Yearbook, 2022.
[16] Loyalka, P., Liu, O. L., Li, G., Kardanova, E., Chirikov, I., Hu, S., ... & Li, Y. (2021). Skill levels and gains in university STEM education in China, India, Russia and the United States. *Nature human behaviour*, *5*(7), 892-904.
[17] Carnoy (2013) compare the college entrance exam score levels of the universe of students entering engineering majors with students entering other majors in regular undergraduate programs in China in 2010 and show that the score levels are very similar.
[18] Source for China: http://en.moe.gov.cn/documents/reports/202209/t20220924_664436.html. Source for the United States: https://nces.ed.gov/programs/digest/d21/tables/dt21_303.70.asp

While, as discussed, students enter college with high levels of language, math, and science achievement, during college they appear to learn very little in terms of academic skills and higher order thinking skills such as critical thinking. Cross-national studies confirm that students in China's four-year public universities make few, if any, gains in math skills and, in fact, lose science skills in the first two years. Furthermore, by the end of four years, graduates in China have comparable levels of major-specific skills and critical thinking skills as graduates in India and Russia and considerably lower major-specific and critical thinking skill levels than graduates in the United States.[19] The lack of learning in these four-year public universities, which are the top tier 1 and 2 universities in the country, implies that the quality of education is perhaps even worse in less-resourced and less-well-managed lower tier colleges (including tier 3 private four-year universities and tier 4 vocational colleges).

Why are undergraduate students in China's university system not learning skills and perhaps even forgetting skills they developed in the K-12 system? It is true that China spends a lot less than the United States per undergraduate student (with China spending approximately $10,000 per student and the United States spending approximately $35,000 per student). A more likely possibility is that students in China are for the most part guaranteed to graduate on-time in four years. They are not allowed to fail their courses in most cases; as part of this, students have little incentive to study for courses and faculty have little incentive to teach well. Once students in China graduate, potential employers are unable to compare students by their college transcripts and instead use the college they were admitted into as a high school graduate as a signal for their ability.

There have been no high-quality studies, that I know of, that look at the quality of graduate education (master's and doctoral programs). Suffice it to say that China produces a very large number of graduate students (from 2012-2021, it produced 6.5 million master's graduates and 600,000 doctoral graduates).[20] Policymakers in China have also been giving considerable attention in the last few years to improving the quality of graduate education. One effort has been to concentrate attention on improving the quality of a smaller proportion of "dual excellence" programs at universities. According to China's Ministry of Education, these programs currently train 60% of master's students and 80% of doctoral students in the country.[21] Whether these programs are currently training high quality graduate students is somewhat doubtful considering the low-quality of the undergraduate experience. However, it is quite possible that the quality of higher education – both at the graduate and undergraduate levels – can improve quite quickly if China invests the requisite resources and effort.

In summary, China has a vigorous education system that is improving in size, accessibility, and quality. The country still faces considerable challenges, however, in addressing rural-urban gaps in educational opportunities and outcomes, gaps that become increasingly manifest after junior high school and which have implications for economic growth, inequality, and social stability. China also has a lot of work to do to improve its vocational and higher education

[19] In addition to Loyalka et al. (2021), see also Loyalka, P., Liu, O. L., Li, G., Chirikov, I., Kardanova, E., Gu, L., ... & Tognatta, N. (2019). Computer science skills across China, India, Russia, and the United States. *Proceedings of the National Academy of Sciences*, *116*(14), 6732-6736.
[20] http://en.moe.gov.cn/documents/reports/202210/t20221022_671529.html
[21] http://en.moe.gov.cn/documents/reports/202210/t20221022_671529.html

systems. Given its strategic importance for national development, it seems highly likely that China will put considerable attention towards improving its higher education system in the years ahead.

OPENING STATEMENT OF ZACHARY M. HOWLETT, ASSISTANT PROFESSOR OF ANTHROPOLOGY, YALE-NUS COLLEGE, NATIONAL UNIVERSITY OF SINGAPORE

COMMISSIONER PRICE: Thank you very much. Dr. Howlett?

DR. HOWLETT: Co-Chair Cleveland, and Co-Chair Price, Commission members and staff, thank you very much for the opportunity to testify at this hearing. My testimony concerns China's national college entrance exam, known as the Gaokao, or high-level exam. I'll be focusing on its role in reinforcing Chinese Party-state political legitimacy.

The Gaokao performs this function by sustaining the perception that the Party-state maintains the basic conditions of meritocracy. A system in which hard work, and merit can lead to success and honor. Held over two days every June 7th and 8th, the Gaokao is the conducting baton of the Chinese education system and the culminating rite of passage of 12 years of schooling.

As the main determinant of college admission, it provides an important path to social mobility. As people in China say, the Gaokao changes fate. Every year some 10 million high school seniors take the Gaokao, representing about half their age group.

The exam is notoriously difficult to cheat on, leading many to see it as an island of transparency and fairness in a system rife with backroom dealing and social connections, or guanxi. All over China, people see the Gaokao as the only relatively fair social competition. The exam is especially fateful for China's hundreds of millions of rural residents and rural to urban migrants.

Despite many reforms, China retains a de facto two-tier system of citizenship. People with rural household residency have inferior access to healthcare, welfare, education, and employment. For many, the Gaokao provides the only viable pathway to urban citizenship and the benefits of a white-collar life. To be sure, preferential admissions quotas favor examinees in metropolitan cities like Beijing, Tianjin, or Shanghai. Still, the Gaokao gives ordinary people a direct, though difficult route to status and power.

From the state's perspective, even those who fail the exam learn a valuable lesson. Rather than blaming social inequality or the Party-state for their failure, they blame their personal failings or bad luck. Instead of rebelling, they strive to give their children a chance to succeed.

People may forget the contents of their textbooks, including ideological indoctrination, but other lessons run deeper. They learn to believe in meritocracy and hitch their personal destiny to the yoke of national development led by the Party-state. But this system is straining under rising inequality and straining economic growth.

In the post Mao era, gaps in test scores and educational opportunities have widened between socio economic groups and regions. Meanwhile, the rapid expansion of higher education in the 21st century has outpaced the creation of job opportunities for new college grads, who face a crisis of un- and underemployment.

Although girls and women are outperforming boys and men, they remain largely locked out of economic and political leadership positions. Exacerbating these unequal trends, automation is killing jobs, and China now faces the silver tsunami of a rapidly aging society. The demographic dividend of plentiful low-wage workers is a thing of the past. But pivoting to an innovation driven service economy requires economic liberalization and equitable access to high quality vocational training, college prep schools, and colleges.

Under General Secretary Xi Jinping, the Party-state is failing to address these challenges. Without a course change, China may not escape the middle-income trap that bedevils so many developing countries.

As growth slows, a whole generation is confronting the idea that China's future may not be as bright as once believed. Hard work and merit no longer seem to guarantee success. This potential crisis of meritocracy is exacerbated by contradictions inherent to the exam system.

As the country attempts to pivot toward innovation, and services, it faces a dilemma. People of rural origin see the exam as fair because it relies on memorization. Reforms to focus on creativity and innovation tend to benefit relatively privileged urban children who have access to creativity building extracurricular activities, such as hands on scientific research experience. Already, the higher education system is heavily stratified with urbanites dominating in elite colleges. Every shift towards focusing more on selecting for creativity further alienates and marginalizes people of rural origin.

From a U.S. perspective, this crumbling faith in meritocracy presents both threats and opportunities. A threat is that the Party-state may use more muscular methods to sustain legitimacy, fanning the flames of nationalism, and even initiating armed conflict over Taiwan.

An opportunity is that increasing numbers of educated people are looking abroad for their futures. Whereas the majority of students from China formerly returned to the motherland, this trend may reverse. China may face increasing brain drain. Countries friendly to high skilled immigrants will see an influx of talent.

It will be in the U.S.'s long-term advantage to welcome these young people, who largely maintain a positive image of the United States as a land of opportunity, freedom, and democracy. At the same time, the U.S. should continue the cultural exchanges that have reinforced these positive views.

Generations of Chinese scholars, and students have visited or studied in the U.S. Such exchanges counteract Chinese propaganda and help give Americans a window into social and political developments in China. These interactions are even more important in an era when it is increasingly difficult for Americans to travel to China for in-person research.

For these reasons I recommend fully restoring the China Fulbright Exchange Program, which was suspended in July 2020. Thank you.

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Friday, February 24, 2023

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Testimony before the U.S.-China Economic and Security Review Committee

"China's Challenges and Capabilities in Educating and Training the Next Generation Workforce"

Meritocracy, Political Legitimacy, and the National College Entrance Exam in China

Introduction: The National College Entrance Exam as a Fulcrum of Political Legitimacy in China

China's National College Entrance Exam, known as the Gaokao or High-Level Exam, is a fulcrum of the Chinese Party-state's political legitimacy. The Gaokao sustains people's perception that the Party-state maintains the basic conditions of meritocracy, a system in which hard work and merit can lead to success and honor. The exam is the conducting baton of the Chinese education system and the culminating rite of passage of twelve years of schooling. As the main determinant of college admission, it provides an important path to social mobility. As people in China say, "The Gaokao changes fate." Every year some ten million high school seniors take the Gaokao, or about fifty percent of young people.[1] The exam is notoriously difficult to cheat on, leading many to see it as an island of transparency and fairness in a system rife with corruption and backroom dealing. All over China, people echo a common refrain: In a country where social connections or guanxi are crucial for social advancement, the Gaokao is the only relatively fair social competition.[2]

[1] In 2020 the population of people in China between the ages of 15 and 19 was about 80 million, and over a four-year period about 40 million currently take the Gaokao. I take my population estimates from "Does China Have an Aging Problem?" *China Power*, Center for Strategic & International Studies, February 15, 2016 (Updated March 19, 2020) <https://chinapower.csis.org/aging-problem/>.

[2] For further background on the exam and its role in political legitimacy, see Zachary M. Howlett, "The National College Entrance Exam and the Myth of Meritocracy in Post-Mao China," in *Making Meritocracy: Lessons from China and India, from Antiquity to the Present*, edited by Tarun Khanna and Michael Szonyi, 206–30 (Oxford: Oxford University Press, 2022). See also Zachary M. Howlett, *Meritocracy and Its Discontents: Anxiety and the National College Entrance Exam in China* (Ithaca, NY: Cornell University Press, 2021a). For a general cultural overview of the Chinese schooling system, see Andrew B. Kipnis, *Governing Educational Desire: Culture, Politics, and Schooling in China* (Chicago: University of Chicago Press, 2011).

The exam, the main part of which is held every year on June 7 and 8, is especially fateful for China's hundreds of millions of rural residents and rural-to-urban migrants. Despite many reforms, China retains a de facto two-tier system of citizenship, in which people with rural household residency have inferior access to healthcare, welfare, education, and employment. For many the Gaokao provides the only viable pathway to urban citizenship and the benefits of an elite white-collar life. To be sure, preferential admissions quotas favor examinees in metropolitan cities like Beijing, Tianjin, and Shanghai. Still, the Gaokao gives ordinary people a direct though difficult route to status and power (Figure 1).

By one route or another, many leaders of government and industry are selected from high scorers. People see successful examinees as personifying the cultural virtues of diligence, persistence, composure, and good luck. From the state's perspective, even those who fail the exam learn a valuable lesson. Rather than blaming social inequality or the Party-state for their failure to transform destiny, they blame their personal failings or bad luck. Instead of rebelling, they strive to give their children a chance to succeed. People may forget the contents of their textbooks, including ideological indoctrination, but other lessons run deeper. They learn to believe in meritocracy and hitch their personal destiny to the yoke of national development led by the Party-state.

But this system is straining under rising inequality and slowing economic growth. In the post-Mao era, gaps in test scores and educational opportunities have widened between socioeconomic groups and regions.[3] Many people in rural areas do not have access to adequate nutrition, a basic requirement for healthy development let alone meritocratic competition.[4] Meanwhile, the rapid expansion of higher education in the twenty-first century has outpaced the creation of job opportunities for new college grads, who face an unprecedented crisis of un- and underemployment exacerbated by the Covid pandemic, with youth unemployment now around 20 percent.[5] Although girls and women are outperforming boys and men, they remain largely locked out of economic and political leadership positions.[6] Exacerbating these unequal trends, automation is killing jobs and

[3] See Howlett, *Meritocracy and Its Discontents,* chapter 3.
[4] See Scott Rozelle and Natalie Hell, *Invisible China: How the Urban-Rural Divide Threatens China's Rise* (University of Chicago Press, 2020).
[5] Financial Times, "China's High Youth Unemployment Stokes Student Covid Protests," November 30, 2022 <https://www.ft.com/content/7d286faf-dccd-453a-a413-470babc7f1cc>. Ka Ho Mok and Alfred M. Wu, "Higher Education, Changing Labour Market and Social Mobility in the Era of Massification in China," *Journal of Education and Work* 29.1 (2016): 77–97. <https://doi.org/10.1080/13639080.2015.1049028>.
[6] Xiaorong Gu and Jean Wei-jun Yeung, "Why Do Chinese Adolescent Girls Outperform Boys in Achievement Tests?" *Chinese Journal of Sociology* 7.2 (2021): 109–37 <https://doi.org/10.1177/2057150X211006586>. Zachary M. Howlett, "Tactics of Marriage Delay in China: Education, Rural-to-Urban Migration, and 'Leftover Women,'" in *Waithood: Gender, Education, and Global Delays in Marriage*, edited by Marcia C. Inhorn and Nancy S. Hefner, 177–99 (New York: Berghahn, 2021b) <https://doi.org/10.1515/9781789209006-010>.

China now faces the "silver tsunami" of rapid social aging.[7] The demographic dividend of plentiful low-wage workers is a thing of the past, but pivoting to an innovation-driven service economy requires economic liberalization and equitable access to high-quality vocational training, college-prep schools, and colleges.

Under General Secretary Xi Jinping, the Party-state is failing to address these challenges. Without a course change, it is difficult to see how China can escape the middle income trap that bedevils so many developing countries.[8] As growth slows, a whole generation of youth is confronting the idea that China's future may not be as bright as they once believed. Hard work and merit no longer seem to guarantee success. This disillusionment with meritocracy is reflected in the growing interest in "lying flat" (*tangping*), analogous to quiet quitting, and the cultural buzzword "involution" (*neijuan*), which describes escalating social competition for diminishing gains.[9]

This potential crisis of faith in meritocracy is exacerbated by contradictions inherent to the exam system. As the country attempts to pivot toward innovation and services, it faces a dilemma. People of rural origin see the exam as fair because it relies on memorization. They say that no special equipment or extraordinary opportunity is required; anyone with access to school textbooks can succeed. Reforms to focus college admissions on selecting for creativity and innovation tend to advantage relatively privileged urban children, who have access to creativity-building extracurricular activities such as hands-on scientific research experience. Already, the higher-education system is heavily stratified, with urbanites dominating the enrollment in top colleges. Every shift toward focusing more on selecting for creativity further alienates and marginalizes people of rural origin.

From a U.S. perspective, this crumbling faith in meritocracy presents both threats and opportunities. A threat is that the Party-state may use more forceful or ideological methods to sustain legitimacy. China's leadership will continue fanning the flames of nationalism and may even initiate armed conflict over Taiwan. An opportunity is that increasing numbers of educated Chinese youth are looking abroad for their futures. Whereas the majority of students from China formerly returned to the motherland, this trend may reverse as increasing numbers adopt a so-called "run philosophy" (*runxue*).[10]

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[7] Carl Minzner "China's Doomed Fight Against Demographic Decline," June 27, 2022 <https://www.foreignaffairs.com/articles/china/2022-05-03/chinas-doomed-fight-against-demographic-decline>.

[8] Rozelle and Hell, *Invisible China*. See also David L. Shambaugh, *China's Future* (Cambridge: Polity, 2016).

[9] On "lying flat," see Elsie Chen, "These Chinese Millennials Are 'Chilling,' and Beijing Isn't Happy" *New York Times*, July 3, 2021 <https://www.nytimes.com/2021/07/03/world/asia/china-slackers-tangping.html>. For a discussion of involution, see Qianni Wang and Shifan Ge, "How One Obscure Word Captures Urban China's Unhappiness," *Sixth Tone*, November 4, 2020 <https://www.sixthtone.com/news/1006391/https%3A%2F%2Fwww.sixthtone.com%2Fnews%2F1006391%2Fhow-one-obscure-word-captures-urban-chinas-unhappiness>.

[10] Li Yuan, "'The Last Generation': The Disillusionment of Young Chinese." *New York Times*, May 24, 2022. <https://www.nytimes.com/2022/05/24/business/china-covid-zero.html>.

China will face increasing brain drain, and countries friendly to high-skilled immigrants will see an influx of new talent.

Although the fabric of meritocracy is fraying, ordinary people in China remain widely committed to the Gaokao, China's "only relatively fair competition." They devote their days to preparing themselves, their children, and grandchildren for success in the exam. Much like the imperial era civil examinations, which the country used to select its governing elite for over a millennium (960–1905), the Gaokao serves as a cultural gyroscope, uniting diverse groups in a diligent drive for social mobility and the common pursuit of their most cherished cultural values.[11] Understanding the exam and the meritocratic system that it undergirds is crucial to understanding how the Chinese Party-state constructs and sustains political legitimacy.

Historical Background: The Gaokao in the Mirror of World History

Meritocracy is a defining characteristic of the modern world and forms a common denominator between democratic and authoritarian societies. People almost everywhere believe that hard work and intelligence, rather than hereditary privilege, should bring honor and success. They use examinations and examination-based credentials to select winners and losers in school, higher education, work, and public life.

Of course, this form of selection has always had its critics: those who say that standardized tests produce standardized minds, or those who complain that only the wealthiest have the resources to rise to the top.[12] But recent decades have witnessed a troubling rise in inequality globally.[13] In almost every country on Earth, the gap between the rich and the poor is widening, propelled by economic and technological changes that we have only just begun to grasp. This increasing stratification of society is accompanied by an increasing stratification of educational institutions. An elite few are increasingly monopolizing access to the best institutions, attendance of which is an important predictor of future opportunity and income.[14]

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[11] For a brief introduction to the imperial civil exam, see Benjamin A. Elman, "Late Traditional Chinese Civilization in Motion, 1400–1900," in *Motion and Knowledge in the Changing Early Modern World*, edited by Ofer Gal and Yi Zheng, 169–88 (Dordrecht: Springer Netherlands, 2014). For a deeper dive, see Benjamin A. Elman, *Civil Examinations and Meritocracy in Late Imperial China* (Cambridge, MA: Harvard University Press, 2013).

[12] See, for example, Pierre Bourdieu, "The Forms of Capital," in *Handbook of Theory and Research for the Sociology of Education*, edited by John G. Richardson, translated by Richard Nice, 241–58 (New York: Greenwood Press, 1986). For a critique of the SAT's role in U.S. college admissions, see Joseph A. Soares, ed. *SAT Wars: The Case for Test-Optional College Admissions* (New York: Teachers College Press, 2012). For a critique of the Gaokao, see Dongping Yang, *Zhongguo jiaoyu gongping de lixiang he sianshi* (The Ideal and Reality of Chinese Educational Fairness) (Beijing: Peking University Press, 2006).

[13] Branko Milanović, *Global Inequality: A New Approach for the Age of Globalization* (Cambridge, MA: Belknap, 2016).

[14] Wei-Jun Jean Yeung, "Higher Education Expansion and Social Stratification in China," *Chinese Sociological Review* 45, no. 4 (July 1, 2013): 54–80. Joseph A. Soares, *The Power of Privilege: Yale and America's Elite Colleges*. Stanford, CA: Stanford University Press, 2007.

Although these problems are global, they have unique historical resonance in China, which preceded Europe in the transition from aristocracy to merit-based leadership by many hundreds of years (Figures 2 and 3). The development of open, anonymous, competitive civil examinations in China during the Song Dynasty (960–1279) formed a watershed event in China's early modern era (960–1912), which was characterized by widespread bureaucratization, commercialization, and urbanization.[15] But at the end of China's last imperial dynasty, the Qing (1644–1912), the Chinese state struggled with internal strife and Western colonial incursion.[16] Reformers argued that the exam system, which focused on the Confucian classics, had stymied China's modernization. It was abandoned in 1905, on the cusp of China's Republican Revolution (1911–12), although some historians contend that the Qing state might have survived if it had reformed its exam system instead of abolishing it.[17] Ironically, just as China was discarding competitive national exams, other countries were instituting them, often under the influence of Chinese models.[18]

During the Republican Era (1912–49), the country entered a period of weak central control, warlordism, and civil war. Newly founded Western-style institutions of higher education administered separate entrance exams. During this period, the absence of national examinations contributed to the alienation of Chinese elites from state power.[19] Following the Communist Revolution of 1949, one of the new government's first priorities was to implement a unified national examination system. In 1952 the Communist government held its first Gaokao, bringing elites firmly back into the orbit of a newly consolidating state.

The renationalization of examinations under Communist rule—albeit now under the influence of Soviet and Western models—accompanied the re-establishment of centralized state authority after decades of disunity. In the following years, the state has constantly tinkered with the examination to adapt it to changing circumstances, but except for the hiatus during the Cultural Revolution (1966–76), the Gaokao has formed a perennial national rite to this day.

The Cultural Revolution was a period in which people earnestly questioned the belief that merit is an individual achievement rather than a collectively produced good. Students decried examinations as a "right-wing, capitalist" institution. They tore up their

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[15] John W. Chaffee, *The Thorny Gates of Learning in Sung China: A Social History of Examinations*, New ed (Albany: State University of New York Press, 1995); Elman, *Civil Examinations and Meritocracy in Late Imperial China*.

[16] Unlike India, China was never fully colonized, and historians generally refer to the colonial period in China (1839–1911) as "semi-colonial."

[17] Alexander Woodside, *Lost Modernities: China, Vietnam, Korea, and the Hazards of World History* (Cambridge, MA: Harvard University Press, 2006).

[18] Woodside, *Lost Modernities*. See also Ssu-yü Teng, "Chinese Influence on the Western Examination System: I. Introduction," *Harvard Journal of Asiatic Studies*, 7.4 (1943), 267–312 <http://www.jstor.org/stable/2717830>;

[19] Wen-Hsin Yeh, *The Alienated Academy: Culture and Politics in Republican China, 1919–1937* (Cambridge, MA: Council on East Asian Studies, Harvard University, 1990).

examination papers and demanded that they be allowed to take tests in teams. Following the height of activism from 1966 to 1968, universities were closed completely. For a few years from their reopening in 1972 to the end of the Cultural Revolution in 1976, admission to college was based on a recommendation system that gave preference to the children of workers and peasants. Looking back on the suspension of the Gaokao, critics say that it turned back the clock on China's development by throttling the training of technocratic talent.[20] But the Cultural Revolution was also a period of rapid improvement in equity of access to education.[21] In the countryside, villages mobilized to build vast numbers of new schools. Enrollments soared, with teachers emphasizing practical skills and basic literacy.

When the Gaokao was reintroduced in 1977, state planners reassembled a hierarchical ladder of success. The state established a new category of highly selective so-called keypoint schools to train the next generation of leaders.[22] But ordinary people fell behind. When children of the 1980s came of age in the early 2000s, China's literacy rates suffered a marked drop.[23] Nine years of compulsory education was declared a national policy in 1986, but China did not make real progress toward this goal until the 1990s when the effect of state-imposed controls on population growth, the Birth Planning Policy, began to be felt.[24] Introduced in 1979, this policy reduced the number of children, especially in urban areas, making it easier to implement education for all.

With the resurgence of examination-based meritocracy in post-Mao China, the composition of the elite has changed substantially. In the Maoist era (1949-1976), the elite largely consisted of Party cadres from the Communist revolution. In the post-Mao era of economic reform (1976-present), an entrepreneurial elite of wealthy business people has emerged. Simultaneously, the Party has become increasingly technocratic, filling its ranks with Communist engineers, lawyers, and economists.[25] Party membership has become strongly correlated with success in meritocratic competitions.[26]

Prior to the 1990s, college graduates were virtually guaranteed employment for life—an "iron rice bowl"—in a government work unit. People in China often compared graduates of that time to imperial era degree holders, who were guaranteed an annual stipend paid in rice. In the 1990s, however, officials accelerated the dismantling of the state-planned

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[20] Haifeng Liu, *Gaokao gaige de lilun sikao* (Theoretical reflections on reform of the Chinese College Entrance Examination) (Wuhan: Central China Normal University Press, 2007).
[21] Joel Andreas, "Leveling the Little Pagoda: The Impact of College Examinations, and Their Elimination, on Rural Education in China," *Comparative Education Review*, 48.1 (2004), 1–47 <http://dx.doi.org/10.1086/379840>.
[22] Stig Thøgersen, *Secondary Education in China after Mao: Reform and Social Conflict* (Aarhus, Denmark: Aarhus University Press, 1990).
[23] Yasheng Huang, *Capitalism with Chinese Characteristics: Entrepreneurship and the State* (Cambridge: Cambridge University Press, 2008), pp. 244–45.
[24] Andreas, "Leveling the Little Pagoda," p. 33.
[25] Joel Andreas, *Rise of the Red Engineers: The Cultural Revolution and the Origins of China's New Class* (Stanford, CA: Stanford University Press, 2009).
[26] Elizabeth Perry, "Educated Acquiescence: How Academia Sustains Authoritarianism in China," *Theory and Society*, 49.1 (2020), 1–22 <https://doi.org/10.1007/s11186-019-09373-1>.

work-assignment system and expanded higher-education enrollment, producing rapid degree inflation. Now only a degree from an elite college provides comparable prestige and security. Although the definition of an elite degree has shifted many times from the imperial era to the present, the importance of possessing one has not. Now as before, excelling on examinations secures one's status within a state-certified national hierarchy of credentials.

For these reasons, people in China often see the Gaokao as the cultural continuation of the imperial era civil exams. As a provincial level education official told me, "Like the imperial exams of old, the Gaokao gives the common people hope." And as a rural high school principal said, "Without the Gaokao, there would be a social revolution."

Because of the social and political significance of the Gaokao, the highest echelons of state power routinely interfere in its management. In 1989, the student-led Tiananmen protests—partly a response to runaway inflation—threatened to topple the regime. The state responded violently by massacring protesters. But afterwards it pursued a seemingly contradictory strategy: Instead of clamping down on college enrollment, state leaders increased the number of college students, which rose from 670,000 in 1988 to 980,000 in 1993, even as it tightened ideological controls (Table 1).[27] Around the same time, starting in 1995, the administration of then Party leader Jiang Zemin (served 1989–2002) poured billions of dollars into China's top universities to form Project 211, an abbreviation of twenty-first century and one hundred, the approximate number of participating universities. The more exclusive Project 985—named for the year (1998) and month (May) of its inception—funneled even greater sums of money into China's forty most elite research universities. These investments aimed to jumpstart China's innovation economy and to strengthen the ties between state and scholar.[28] To further stimulate innovation, the central state devolved the authority to design the Gaokao onto provinces, each of which became a laboratory for education reform. Beginning in the early 2000s until the recentralization of exam design starting in 2016, there was no single national standard for the exam. In practice, most provinces, as I note below, followed a similar format, but some, including Jiangsu Province, differed widely from that model and others, such as Zhejiang Province, piloted reforms that later became adopted nationally.[29]

In the late 1990s, the regime experienced another threat to its survival when the Asian Financial Crisis shook public confidence in Party-led national development. The politburo, the highest decision-making body of the Chinese Communist Party (CCP), responded by ordering another expansion of higher-education recruitment, overriding the gradualist plans of the Ministry of Education. This time the expansion assumed epic

[27] Howlett, *Meritocracy and Its Discontents.*
[28] Perry, "Educated Acquiescence."
[29] Some argue that this form of continual experimentation and transformation forms a secret of the Chinese regime's resilience. See Sebastian Heilmann and Elizabeth J. Perry, "Embracing Uncertainty: Guerrilla Policy Style and Adaptive Governance in China," in *Mao's Invisible Hand: The Political Foundations of Adaptive Governance in China*, ed. by Sebastian Heilmann and Elizabeth J. Perry, Harvard Contemporary China Series, 17 (Cambridge, Ma: Harvard University Asia Center, 2011), pp. 1–29.

proportions. Over the next decade, the number of students in college quadrupled from 5 million to 20 million between 1999 and 2009 and now hovers over 33 million.[30] By taking this measure, state leaders hoped to increase economic consumption by tapping into unmet demand for higher education as well as binding broader swaths of the population into the myth of meritocracy.[31] As a result of the expansion, the majority of examinees, around 80 percent, now get into some kind of college. More people than ever before are going to college, but educated unemployment is surging, and the majority of college grads now earn less than the average migrant worker.[32]

Today, China faces another brewing economic storm, which threatens to aggravate this employment crisis. The state staved off the worst of the 2008 global financial crisis by injecting credit into China's economy, but this action produced colossal levels of bad debt and exacerbated already high levels of corruption. At the same time, China's economic expansion is finally slowing after decades of double-digit growth largely fueled by cheap labor. As wages rise, many industries are automating or moving abroad, and leaders worry that China may not be able to jump over the middle-income trap that bedevils developing countries.[33] As part of their response to these challenges, officials are pursuing another round of examination reforms under Xi Jinping, the current Party leader (2012–present). Like earlier reforms, these measures aim to accelerate China's transition to a consumption-based innovation economy. But they are also congruous with the anti-corruption campaign that has largely defined Xi's leadership.[34] Reversing the devolution of exam design to the provinces in the 2000s, the state now designs the compulsory sections of the Gaokao—math, English, and Chinese—in Beijing. By reclaiming central state control over the test, which is widely perceived to have fallen prey to corrupt local politics and special interests, these reforms aim to bolster people's faith in this pillar of China's meritocracy.

The direct intervention of the highest levels of government in the exam system reveals the degree to which central-state leadership considers the legitimacy of the examination to have implications for the legitimacy of Party rule. Party leaders take the exam so seriously because of its important role in maintaining belief in meritocracy. China watchers often suggest that Chinese political legitimacy rests on a tacit bargain: People

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[30] See the National Bureau of Statistics of China's annual data at <http://www.stats.gov.cn/english/Statisticaldata/AnnualData/>, which goes up to 2019. The above numbers include only students enrolled in regular higher education institutes. If students in adult and web-based higher education institutes are included, the current number is close to 45 million.

[31] Qinghua Wang, "Crisis Management, Regime Survival and 'Guerrilla-Style' Policy-Making: The June 1999 Decision to Radically Expand Higher Education in China," *The China Journal*, 71 (2014), 132–52 (p. 151) <https://doi.org/10.1086/674557>; Howlett 2021a.

[32] Yanjie Huang, "China's Educated Underemployment," *East Asian Policy*, 5.2 (2013), 72–82 <https://doi.org/10.1142/S1793930513000172>.

[33] Shambaugh, *China's Future*.

[34] David Cohen and Nathan Beauchamp-Mustafaga, "Anti-Privilege Campaign Hits the Chinese Middle Class," *China Brief*, 14.17 (2014), 1–3 <https://jamestown.org/program/anti-privilege-campaign-hits-the-chinese-middle-class/>.

acquiesce to Party-state rule in exchange for wealth. In this view, people in China support the Party because economic development has improved their lives. But this focus on development overlooks the significance of merit. People do not so much expect their lives to improve under Party rule as they expect to have opportunities to improve their lives. In other words, people expect the state to guarantee the conditions for the meritorious to advance. At minimum, it must ensure the perception that such conditions exist. Like the imperial exams of old, the Gaokao reinforces this perception because it forms a national fateful rite of passage that is open, anonymous, and competitive.

The Structure of the Exam System and the Nationalist Ideology of Developmentalism

Most provinces in China have a six-three-three system of education: six years of primary school, three years of junior high school (termed *chuzhong*) and three years of senior high school (termed *gaozhong*). The state now reports near universal compliance with nine-year compulsory education. In reality, however, many children in rural areas drop out to work before finishing grade nine.[35] The state now intends to roll out twelve years of free compulsory education, and has begun doing so in some cities and rural areas. But just as compliance with nine-year education was incomplete, people on the ground say that this is *a fortiori* true of attempts to institute twelve-year education, especially in rural areas. The one-child policy, which lasted from 1979 to 2015, was never strictly enforced in rural places, where household incomes are also lower and prospects bleaker.[36] Rural children who do not excel in school often face financial pressure to start supporting their families and younger siblings. Because high schools after grade nine are not free, only the most academically diligent and talented students will receive support from cash-strapped families. Young people who drop out often move to the cities to work. Lacking urban household registration, they toil as undocumented or semi-documented laborers.

After students complete junior high school, they take the high school entrance examination, termed the *zhongkao*. The quota for passage of the high school entrance examination is set around 50 percent in most places, meaning that around half of China's youth population take the Gaokao (with the caveat that an unknown number drop out before grade 9). Those who succeed go on to academic senior high schools. Some of those who fail go to vocational schools, and the government has been trying to improve vocational education. Despite massive investments and much lip service paid to improving vocational education, however, its quality remains low and it is culturally

[35] Rozelle and Hell, *Invisible China*. See also Yi, Hongmei, Linxiu Zhang, Renfu Luo, Yaojiang Shi, Di Mo, Xinxin Chen, Carl Brinton, and Scott Rozelle, "Dropping Out: Why Are Students Leaving Junior High in China's Poor Rural Areas?" *International Journal of Educational Development* 32.4 (2012): 555–63. <https://doi.org/10.1016/j.ijedudev.2011.09.002>.

[36] In many provinces, the official policy was to allow people in rural areas to have a second child if the first was a daughter, a concession to cultural preference for sons. Many families, particularly in China's southern provinces, found ways to skirt the policy. It was common for parents to "keep trying" until they produced male offspring. See, for example, Quanbao Jiang and Zhang Cuiling Jiang, "Recent Sex Ratio at Birth in China," *BMJ Global Health* 6.5: 1–11 (2021) <http://dx.doi.org/10.1136/bmjgh-2021-005438>.

unattractive in a society that deems attendance of vocational school a personal and academic failure.[37]

All around China, senior high schools are organized into hierarchies by the average test score of students they admit. Families strive to send their children to the best high schools, admission to which is the best predictor of superior performance in the College Entrance Exam or Gaokao. Whereas attendance of public primary and junior high schools is free of charge, senior high schools charge tuition. Thus senior high schools operate on a "pay to play basis," with schools charging between RMB 1,000 and 5,000 per year ($150 to $740). Fees are even higher for underperforming students, who may pay extra "school selection fees" if they did not meet the cut-off score for their desired high school. Such fees are expensive for average families, especially those from rural backgrounds; however, many willingly pay them because of their faith in the Gaokao's ability to change fate and the cultural importance attached to educational credentials. Although the average migrant worker has earned more than the average college grad since 2011, people in China continue to see the attainment of advanced educational credentials and a white-collar career path as superior to blue-collar work, even if skilled and unskilled labor pay better.[38] As a time-honored Chinese saying goes, "Among all the pursuits known to humankind, learning is the noblest."

In Chinese academic high school, students study math, Chinese, a foreign language (typically English), history, geography, chemistry, biology, and "ideology and politics" (*sixiang zhengzhi*), typically shortened to "politics."[39] The latter is a mixture of Chinese Marxism and ethics and forms a core element of political indoctrination. But rather than buying into the contents, students generally see them as something that needs to be memorized to pass exams. As one boy of rural origin remarked to me with a grin and wink after getting a politics quiz back from his teacher, "It's all socialist brainwashing."

Although attempts to indoctrinate students in official ideology through the politics course and related initiatives of "patriotic education," like the weekly flag-raising ceremony, are of questionable effectiveness, official state ideology is embedded in the Chinese education system in a much more implicit and therefore effective way: The goal of doing well on the Gaokao is to get admitted to a good university in a big city, paving the way to migrate up the rural-urban hierarchy and thus to transform the fate of oneself and one's family. Those who succeed in this enterprise receive official state recognition in the form of a high Gaokao score and admission to a top university. They thus naturally tend to recognize the legitimacy of the state, which has recognized their merit. Those who fail tend not to blame structural inequalities, economic problems, or government policies but rather themselves for not possessing the grit and talent required to succeed. Many also reach to religious explanations, blaming fate or luck for their failure and crediting these powers for their success. But such religious explanations often reinforce meritocratic

[37] Rozelle and Hell 2020. See also Terry E. Woronov, *Class Work: Vocational Schools and China's Urban Youth* (Stanford, CA: Stanford University Press, 2015).
[38] Yanjie Huang, "China's Educated Underemployment."
[39] Howlett, *Meritocracy and Its Discontents*, chapter 1.

thinking by expanding it to notions of karmic reciprocity: Success blesses those who have done good deeds in this or past lives.[40] Thus, preparing for the Gaokao, quite aside from the explicit contents of textbooks, which are often soon forgotten, can be said to instill a deeper belief in the ideology of meritocracy that forms an important cornerstone of Chinese state legitimacy.

Part of this ideology of meritocracy in China is a belief in the narrative of national development, another key element of the Party-state's legitimacy. Even if students reject Chinese Marxism as "brainwashing," they "vote with their feet" for the Party-supported narrative of national development by using education to migrate from underdeveloped rural areas to modern urban ones.

This developmentalist narrative is deeply embedded in nationalist history. Unlike many of the Marxist orthodoxies presented in Politics class, nationalist history is presented not only in school but in primary socialization within the family and in popular cultural media like movies, TV series, and computer games. Because of its broad sources of reinforcement, it has broader roots. According to nationalist history narratives, China was deeply humiliated during the first and second Opium Wars (1839–42 and 1856–60), when it was forced through gunboat diplomacy to cede trade concessions to Western powers through a series of unequal treaties and most-favored nations clauses. This humiliation was exacerbated by, among other things, China's treatment in the Treaty of Versailles (1919) following the First World War, when China was forced to cede Shandong Province to Japan, and during Japanese occupation of China in the Second Sino-Japanese War (1937–45).

Especially in the case of the Opium Wars, perceived as the original sin of Western colonialism in China, some historians argue that this narrative is anachronistic: From the perspective of the waning Qing dynasty, which was dealing with autochthonous structural problems such as rural-urban inequality that would last into the twentieth and twenty-first centuries, the problem of Westerners demanding trade concessions was dwarfed by more pressing concerns.[41] From 1850 to 1864, one of the largest civil wars in world history raged in China, the Taiping Rebellion, which nearly toppled the Qing dynasty.[42] This is not to negate or deny the depredations of Western colonialism, but to point out that nationalist histories are arguably constructed around overemphasizing Western impact and colonial violence rather than starting from a point of view that prioritizes long-term historical trends and realities that originate within China and its changing positions within a globalizing world.[43]

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[40] Howlett, *Meritocracy and Its Discontents*, chapter 6. See also Zachary M. Howlett "Performative Secularism: School-Sponsored Prayer in China's National College Entrance Exam." *Critical Asian Studies* 54.3 (2022): 441–69 <https://doi.org/10.1080/14672715.2022.2099439>.
[41] Paul A. Cohen, *Discovering History in China: American Historical Writing on the Recent Chinese Past*, (New York: Columbia University Press, 1984).
[42] Platt, Stephen R, *Autumn in the Heavenly Kingdom: China, the West, and the Epic Story of the Taiping Civil War* (New York: Alfred A. Knopf, 2012).
[43] Cohen, *Discovering History in China*.

Still, the CCP reinforces the narrative of national humiliation, which resonates culturally in popular media, and few people in China question this history, which forms a sacred component of the national culture.[44] According to this culture, China and Chinese people have a national duty to overtake the West through development so that China can erase its humiliation and reassume its rightful place as the Central Kingdom, something the government refers to as "the great rejuvenation." The CCP's sacred mission is to lead the people to this goal.

By perpetuating this narrative, the CCP reinforces a form of psychological colonization, in which the West is held up as the paragon of development and China's imperial history is presented as a great but inflexible tradition that could not withstand the onslaught of Western colonialism.[45] This narrative arguably overemphasizes Western impact and forgets or dismisses China's long and dynamic history of running a complex, early modern bureaucratic state since at least the Song Dynasty (960–1279), including a meritocratic examination system that influenced the modernization of education elsewhere.[46]

The psychological colonization perpetuated by this narrative of national humiliation and the desire to "overtake the West" reinforces CCP legitimacy in several ways.[47] People in rural areas see themselves as "backward" and "inferior," desiring to move to central places, which are seen as centers of modernity, where people are closer to the goal of "overtaking the West." To be sure, this desire to move to the cities is materially reinforced by the real development gaps between countryside and city and by the hukou or household-registration system, which relegates urban residents to second-class citizenship. Yet the hukou system is a state-enforced policy, not a natural fact, and the development gap of the countryside is partly the result of policy decisions. China is lauded for its world-historical achievement of bringing hundreds of millions of people out of poverty, but the rapidest period of poverty reduction occurred in the 1980s, when state policy helped unleash the suppressed entrepreneurial energy in the countryside, whereas in the 1990s and 2000s, resources and investments have flowed into the cities, exacerbating the rural-urban gap.[48]

Thus the psychological colonialism is accompanied by a "hard" form of internal colonialism in which people of rural origin are exploited in an unequal migrant labor regime that is reinforced by their lack of urban citizenship and documentation, much as many business and farm owners in the US rely on undocumented labor migrants from Latin America. In China's southwestern and western ethnic minority peripheries, including Xinjiang and Tibet, this nationalist development narrative justifies an even harder form of internal colonialism in which people's ethnic identity, considered to be

[44] Zheng Wang. *Never Forget National Humiliation: Historical Memory in Chinese Politics and Foreign Relations* (New York: Columbia University Press, 2012).
[45] Howlett, *Meritocracy and Its Discontents*, chapter 2.
[46] Cohen, *Discovering History in China*; Woodside, *Lost Modernities*.
[47] Howlett *Meritocracy and Its Discontents,* chapter 2.
[48] Yasheng Huang, *Capitalism with Chinese Characteristics*.

more "primitive" than the Han majority, is actively repressed.[49] This form of imperialism has roots in China's imperial era, when ethnic minority groups were perceived as closer to animals and the Confucian state felt a duty to humanize them by transforming them through education.[50] But whereas the last imperial dynasty, the Qing, was itself ruled by a minority group, the Manchu, and ruled China as a multi-ethnic empire that maintained many ethnic identities and hierarchies, the CCP, especially in the twenty-first century, has increasingly tended toward Sinicizing minorities.[51] As the coercive policies pursued in Tibet and Xinjiang show, this policy of cultural erasure and Sinicization can take on genocidal proportions.[52] To be sure, people in minority areas can take special versions of the Gaokao in their minority languages and are often given bonus points on the exam.[53] However, they often find themselves shuttled into low-paying and relatively marginalized occupations—for example, as translators and teachers of minority languages—which reinforces their marginalization.[54]

As the only way feasible way for most people of rural origin to acquire urban hukou or citizenship, the Gaokao gives people a way to pursue personal development and to transform the fates of their families. Although they may not believe in orthodox Marxism, the realities of national development are inescapable. By pursuing personal development and becoming a person of quality with an urban hukou, they are pursuing Party-state definitions of national development and reinforcing the Party's developmentalist narrative. At the same time, though few would say they believe in the niceties of Marxism presented in politics class, even fewer would question the narrative of national humiliation that helps to sustain the developmentalist enterprise.

The Gaokao and the Myth of Meritocracy

Gaokao-based meritocracy is a "myth" in both senses of the word: an inspiring cultural model and a popular misconception. Even as the Gaokao inspires people to personify high cultural virtues, it encourages them to cling to a chimeric dream of fairness. Those who compete in the Gaokao and those who support them—teachers, parents, and administrators—are painfully aware of this contradiction between social equity and the cultivation of merit, which is definitional to meritocratic systems. Nevertheless, they remain committed to meritocracy as a personal and social ideal. They fervently desire to achieve the recognition that the examination confers and thus willingly submit to its

[49] Darren Byler, *Terror Capitalism: Uyghur Dispossession and Masculinity in a Chinese City*. (Durham: Duke University Press, 2021a). Darren Byler, *In the Camps: China's High-Tech Penal Colony* (New York, NY: Columbia Global Reports, 2021b). Charlene Makley, *The Battle for Fortune: State-Led Development, Personhood, and Power Among Tibetans in China* (Ithaca, NY: Cornell University Press, 2018).
[50] Magnus Fiskesjö, "On the 'Raw' and the 'Cooked' Barbarians of Imperial China," *Inner Asia* 1 (1999): 139–68 <https://doi.org/10.1163/146481799793648004>.
[51] Byler, *Terror Capitalism*; Byler, *In the Camps*.
[52] Byler, *Terror Capitalism*; 2021b.
[53] Naomi Yamada, *Preferential Education Policies in Multi-Ethnic China* (Abingdon, Oxon, UK: Routledge, 2020).
[54] Howlett, *Meritocracy and Its Discontents*, chapter 3.

discipline, training themselves tirelessly in the capacities that success requires. Even many critics of the exam revere it as a fateful rite of passage that forms a quintessential part of what it means to be Chinese.

During the first two decades of the twenty-first century, students in most provinces were tested on the compulsory subjects—math, Chinese, and English—and the humanities or sciences depending on their specialization, which they declared after their first year of high school. The humanities exam consisted of history, geography, and politics (a mixture of ethics and Marxism); the sciences of chemistry, physics, and biology. Under the newest round of Gaokao reforms being gradually rolled out since 2016, Chinese, math, and English continue to be compulsory, but instead of being divided into humanities and sciences tracks, students select their non-compulsory subjects individually as electives.[55] In addition, students are being allowed more than one chance to take the English exam in some provinces. This new structure aims to give students greater autonomy and flexibility. It is also meant to help address the common complaint that a single exam performance can determine life outcomes. But many teachers and parents say that the reformed system is "the same medicine in a new soup." As before, the exam constitutes a unified national ritual. As before, it is the conducting stick of the whole education system. And as before, its main purpose is to select winners and losers.

For ordinary people, the exam remains highly consequential. By serving as a launching pad for a lifetime of white-collar, meritocratic competition, the Gaokao provides a primary route by which they seek to discharge their basic social duties under China's Confucian culture of filial piety. These duties include finding a good marriage partner, having children, and taking care of elders, all of which are built upon the foundation of high Gaokao scores and the benefits that they bring. Of course, as in imperial times, there are other ways of securing elite status than through state-sponsored examinations. For example, a lucky and privileged few enter the elite through business success or by studying abroad. And no one denies the importance of family connections. Many of China's most powerful politicians, including Xi Jinping, are the direct descendants of Communist revolutionary leaders. But those without guanxi see the Gaokao as a relatively fair and thus pure measure of merit.

Because the Gaokao has such fateful consequences, people spend their lives preparing for the exam, taking the exam, and preparing their children to take the exam. They base many important life decisions around these tasks, including saving money for education, buying a house near a good school, and choosing a spouse who can be a good parent (a good cultivator of high exam scores). Since an important goal of all these investments and decisions is to secure the educational success of the next generation, high test scores become an index not only of individual but of family accomplishment.

[55] In an update to the policy, students are now required to choose either physics or history and can select freely from the remaining electives. Before this change was implemented, few students chose physics, which they consider a difficult subject.

But if people are to see the Gaokao as a fateful rite of passage, it is not enough for them to regard the exam as consequential. It must also be perceived as having an undetermined outcome: as providing a real chance to succeed. Of course, the exam can also be chancy in the negative sense of the word. Although much can be gained in the Gaokao, the economic and opportunity costs of failure are also great, particularly for families of modest means. Compulsory schooling ends at grade 9, but many families make great sacrifices to finance the education of a promising student through high school. In a gender division of labor that forms a patriarchal legacy of China's traditional son preference, it is common for elder siblings, particularly girls, to work as migrant laborers to support the education of younger ones, particularly boys. Although high school fees have dropped following reforms in the 2000s, families incur many other educational expenses.

There are many other expenses associated with education. In 2021, General Secretary Xi suppressed the for-profit shadow education sector, which exacerbates educational inequality.[56] But skeptics of the ban on shadow education say that it has increased graduate unemployment, since so many young people worked in the industry, while wealthy parents simply hire private tutors.[57] Even after the ban, urban families seek to find tutors for their children in the expanding *underground* shadow education market that has mushroomed in its wake. In rural areas, many students travel long distances to high school and board on campus, but school dormitories are crowded and noisy, often with eight or more students to a room. Families may strap their budgets to rent a room for promising examinees during their all-important senior year. Other common outlays include various forms of licit or illicit blandishments including the expensive so-called school choice fees for students who missed the mark by a few points on the high school entrance examination, bribes to administrators to arrange for a child to be streamed into a good class, and gifts for teachers to secure favorable treatment. Finally, if a child fails the Gaokao, retaking the exam is difficult and expensive. Because the state has cracked down on public schools offering this service, it is common for repeat examinees to attend a private school at extraordinary expense.

Although many families chafe at the various ways that families of means can use their wealth to improve their children's chances on the exam, they see the final battle itself as relatively incorruptible. Cheating on the Gaokao, although not unheard of, is a criminal offence and made difficult by strict policing. When they register for the exam, test takers must undergo a physical examination, and their state-issued ID, which includes biometric identifiers, is checked again on test day. Proctors police every room, which are also monitored by camera. In many cities, signal-blocking equipment is used to foil high-tech cheats, and examination halls may even be policed by drones. Although it is possible to purchase access to a good school or class, it is notoriously difficult if not impossible to "spend money"—a euphemism for corrupt practices—to improve a Gaokao score. And the centralized design of test papers in Beijing has curbed another corrupt practice:

[56] D. Cohen and Beauchamp-Mustafaga, "Anti-Privilege Campaign Hits the Chinese Middle Class."
[57] Howlett, *Meritocracy and Its Discontents,* pp. 92–93.

Formerly, the teachers of prestigious keypoint schools were invited by provincial officials to design test questions. Though they were cloistered ahead of the exam to avoid leaks, students at their schools inevitably had a better sense of the questions that would appear on the exam because their teachers were directly involved in creating it.[58]

Diligence versus Quality: The Contradiction between Fairness and Innovation

The critique that the Gaokao does not test merit overlooks its cultural significance as a fateful rite of passage, but what about fairness? Does the Gaokao really give people of modest origins a fair chance at breaking their way into the elite?

Critics say no, pointing to, among other things, the decreasing number of people of rural origin in China's elite colleges.[59] Educational expansion has made it possible for vast numbers of people to obtain a higher-education diploma, but the education system has simultaneously become highly stratified. Places at first-tier four-year colleges are increasingly monopolized by coastal, urban, Han ethnic majority elites, while those at second-tier and two-year colleges are occupied by people of rural and ethnic minority backgrounds.[60]

The quest of reformers to make the exam a better test of merit is partly responsible for these unequal outcomes. Since the 1990s, the Chinese education system has increasingly focused on "education for quality," a nebulous concept that includes innovation and creativity.[61] As part of the quality reforms, the Gaokao was designed to include an increasing number of subjective questions, the answers to which cannot be easily memorized. Students with what are termed special abilities—such as aptitudes in art or sports—were given dedicated pathways into elite schools and could take special, easier forms of the Gaokao.[62] Principals of elite high schools were allowed to handpick some students for direct admission to elite colleges, and bonus points on the Gaokao were awarded for placing highly in academic competitions, such as the International Mathematics Olympiad. Some colleges started administering special autonomous admissions exams, allowing students a further way to rack up bonus points.

Such reforms surely help elite colleges to select students whom they deem to be of higher quality. As critics point out, however, they also tend to disadvantage underprivileged examinees, particularly those of rural background. In rural areas, few families have the financial means or cultural knowledge to train students in special abilities or participate

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[58] The non-compulsory sections of the exam continue to be designed in provincial capitals, but the compulsory sections carry such weight that their centralized design has greatly improved the impression of fairness.
[59] Xiaobing Wang, Chengfang Liu, Linxiu Zhang, Yaojiang Shi, and Scott Rozelle, "College Is a Rich, Han, Urban, Male Club: Research Notes from a Census Survey of Four Tier One Colleges in China," *The China Quarterly* 214 (June 2013): 456–70.
[60] Yeung, "China's Higher Education Expansion and Social Stratification."
[61] Kipnis, *Governing Educational Desire*.
[62] Lily Chumley, *Creativity Class: Art School and Culture Work in Postsocialist China* (Princeton, NJ: Princeton University Press, 2016).

in academic Olympiads, and rural principals have little direct admissions largesse to distribute. By the same token, supposedly creativity-encouraging subjective questions on the Gaokao, such as the Chinese essay question, notoriously focus on topics with a marked urban bias, such as popular music or films. And on the English exam, for example, examination designers strive to include topics that they consider modern—that is, urban—such as the latest models of mobile phones. As one Chinese education researcher of rural background quipped, "If raising pigs is ever considered a special ability, then we'll finally see real admissions equality in the Gaokao."

For people of modest backgrounds, including China's hundreds of millions of rural-to-urban migrants, diligence in rote memorization forms a weapon of the weak: a way of surpassing established elites who are privileged and well-connected but may be complacent. As a popular examination slogan goes, "Without the Gaokao, how can you outcompete the second-generation rich [*fu'erdai*]?"

Ironically, however, even as it has served as a weapon of underprivileged classes and groups, diligence also reinforces their marginalization. Those who rely primarily on diligence to compete on the Gaokao, including many women and ethnic minorities as well as people of rural origin, find themselves funneled into specializing in the humanities, the exam content for which is particularly amenable to rote memorization. In Chinese schools, it is common to hear teachers and students opine that women and ethnic minorities may be very diligent but have inferior "logical ability." As a result of such prejudices and structural inequalities, these groups are overrepresented in relatively marginalized and underpaying humanistic fields, like journalism and translation.[63] By contrast, urban men dominate in STEM fields (science, technology, engineering, and math), from which the majority of China's leaders are drawn.

Yet for the first time in Chinese history, women, long forbidden from taking exams, now outachieve men scholastically, whether measured in terms of standardized test scores or educational attainment.[64] In the decade since 2010, women have continued to outnumber men in college. In 2020, they accounted for 54.4 percent of university students despite a distorted sex ratio at birth, 120 boys to 100 girls, and quotas favoring men in some college programs, including arts and communication as well as military and police

[63] Howlett, *Meritocracy and Its Discontents*, chapter 4; Duoduo Xu, "Is Gender Equality at Chinese Colleges a Sham?" *Sixth Tone*, 2018 <https://www.sixthtone.com/news/1002051/is-gender-equality-at-chinese-colleges-a-sham%3F>.

[64] Gu and Yeung 2021, "Why do Chinese adolescent girls outperform boys in achievement tests?" In the early modern era, an unspoken gender ideology excluded women form participating in China's civil examinations. See *Susan Mann, Gender and Sexuality in Modern Chinese History* (Cambridge: Cambridge University Press, 2011). University co-education began in the Republican era (1912–49) and expanded after the 1949 Communist revolution; however, enrollment did not reach gender parity until the 2000s.

academies.[65] In 2016, women outnumbered men in graduate school enrollment for the first time in spite of despite gender discrimination in admissions.[66]

Scholars usually account for women's academic outperformance by pointing to the one-child policy (1979–2015), which empowered urban singleton daughters by forcing families to invest in them educationally.[67] But around 40 percent of women college students are from rural backgrounds, where the one-child policy was rarely strictly enforced and son preference remains common.[68] Although rural daughters took longer to achieve academic dominance, they have caught up: Among rural students, the proportion of girls going to college tripled from 1990 to 2010, and they now outnumber boys.[69] Also, women's educational outperformance is a global phenomenon, occurring in over seventy countries around the world.[70]

Rather than seeing women's educational revolution as a source of national strength, Chinese leadership perceives it as a "boys' crisis" or crisis of masculinity and scapegoats so-called leftover women, thought to be too picky and careerist to marry early, for the looming silver tsunami of social aging.[71] In response, government leaders are cracking down on feminist movements and creating hurdles to divorce while promulgating

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[65] On discriminatory gender quotas in the Gaokao, see Joy Dong, "As Chinese women seek to crack male professions, schools stand in the way," *New York Times*, October 21, 2021 <https://www.nytimes.com/2021/10/21/world/asia/china-schools-gender-bias.html>. See also Leta Hong Fincher, *Leftover Women: The Resurgence of Gender Inequality in China* (London: Verso, 2016). For statistics on women in higher education, see National Bureau of Statistics, "Final statistical monitoring report on the implementation of China national program for women's development (2011–2020)" (2021) <http://www.stats.gov.cn/enGLISH/PressRelease/202112/t20211231_1825801.html> For a recent analysis of sex ratios at birth, see Quanbao Jiang and Zhang Cuiling Jiang, "Recent Sex Ratio at Birth in China," *BMJ Global Health* 6.5: 1–11 (2021) <http://dx.doi.org/10.1136/bmjgh-2021-005438>. As Jiang and Zhang note, the 120:100 figure is for those born in the 2000s, who are now around university age. Since 2010, the ratio has come down, approaching 110 boys to 100 girls in 2015 data. But the sex ratio at birth remains high in southern provinces, including Fujian, and is distorted nationally for third and above births.

[66] Women accounted for 50.6 percent of graduate students in 2016 (National Bureau of Statistics, 2021). The ratio dropped below 50 percent in 2017 and 2018 before rising again to 50.6 percent in 2019 and to 50.9 percent in 2020 (National Bureau of Statistics, 2021). Zheng (2017) argues that women applicants to master's programs are enrolled at lower rates than men despite having superior college records; however, they continue to outnumber men overall because they apply in greater numbers, in part because it is harder for them to find jobs after college owing to gender discrimination. As Liu and Shen (2022) analyze, women are underrepresented in PhD programs.

[67] Vanessa L. Fong, "China's One-Child Policy and the Empowerment of Urban Daughters," *American Anthropologist* 104.4 (2002): 1098–1109 <https://doi.org/10.1525/aa.2002.104.4.1098.Gu and Yeung 2021>. See also Gu and Yeung, "Why do Chinese adolescent girls outperform boys in achievement tests?"

[68] Howlett, "Tactics of Marriage Delay." X. Wang and others, "College Is a Rich, Han, Urban, Male Club."<https://doi.org/10.1017/S0305741013000647>.

[69] Yang Qian and Wang Weiyi, "Gaodeng jiaoyu jihui xingbie bu pingdeng de chengxiang chayi ji qi bianhua yanjiu" (A study of gender inequality in access to higher education in urban and rural areas and its changes). *Fujian shifan daxue xue bao (zhexue shehui kexue ban)* 6 (2019): 151–158.

[70] Marcia Inhorn and Nancy Smith-Hefner, "Introduction," in *Waithood: Gender, Education, and Global Delays in Marriage*, in in *Waithood: Gender, Education, and Global Delays in Marriage*, edited by Marcia C. Inhorn and Nancy S. Hefner, 1–30 (New York: Berghahn, 2021) <https://doi.org/10.1515/9781789209006-003>.

[71] Fincher, *Leftover Women*; Howlett, "Tactics of Marriage Delay"; Minzner, "China's Doomed Fight Against Demographic Decline."

traditional masculinity and family values.[72] Such policies appear to be backfiring, however, because they do not address why women choose not to have children, including unfair distributions of household labor, the rising costs of raising children, China's dimming economic outlook, and the hypercompetitive educational environment. And as a result of continued discrimination and structural inequality, women remain underrepresented in the higher echelons of government and business.[73]

Relatively few reform efforts attempt to address unequal ethnic and gender divisions of labor, probably because they are perceived as resulting from so-called natural differences despite all scientific research to the contrary. Since the 2000s, however, there has been much pushback against the quality reforms. For a long time, the West, and particularly the U.S., has been idealized as a place where the all-around quality of students is recognized.[74] But people say that a U.S.-style multifactor admissions system, which includes essays, letters of recommendation, and high school grades in addition to standardized test scores, would never work in China because it could too easily be corrupted.[75] Many contend that the Gaokao, with all its faults, is relatively fair because it gives anyone with access to public school a chance to make it into the elite.

The Gaokao reforms under Xi Jinping aim to reinforce this perception of fairness. In addition to centralizing the production of exam questions, Xi's reforms have removed many ways to game the system by accumulating bonus points or cultivating special abilities. Under Xi, it has also become easier for the children of migrant workers to take the Gaokao in their place of study rather than having to return to their native provinces to sit for the exam, a requirement that further disadvantaged this already underprivileged cohort of test-takers.[76] In addition, the reforms under Xi encourage universities to increase admission quotas for students from rural areas as well as from inland and Western provinces, where the majority of China's ethnic minorities reside. Such quotas can be conceived as a form of affirmative action, although they are not perceived as

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[72] Leta H. Fincher, *Betraying Big Brother: The Feminist Awakening in China* (London: Verso, 2018).
[73] See Sierra Janik, Daniel Blaugher, and Jonathan Ray, "Women in China's Leadership," U.S.-China Economic and Review Commission Issue Brief, March 30, 2022 <https://www.uscc.gov/sites/default/files/2022-03/Women_in_Chinas_Leadership.pdf>.
[74] Ironically, U.S. primary and secondary education has shifted post-2000 to focus more on standardized testing, partly to counter the perceived threat of rising Chinese educational dominance.
[75] Multifactor admissions do not always seem to work in the United States either. In a 2019 admissions scandal, American parents were criminally prosecuted for paying fixers to gain entry for their children to elite colleges. This incident probably forms the tip of the iceberg. See Jennifer Medina, Katie Benner, and Kate Taylor, "Actresses, Business Leaders and Other Wealthy Parents Charged in U.S. College Entry Fraud," *New York Times*, 12 March (2019). <https://www.nytimes.com/2019/03/12/us/college-admissions-cheating-scandal.html>.
[76] This policy change was a hard-won accomplishment of the New Citizens' Movement (*Xingongmin yundong*), a series of grassroots civil rights campaigns that, among other actions, collected the signatures of more than 100,000 migrant workers who were impacted by Gaokao residency restrictions. See *New Citizens Movement Briefing Note* (Human Rights in China, 2014) <https://www.hrichina.org/sites/default/files/new_citizens_movement_briefing_note_2014.pdf>.

compensating disadvantaged groups for historical injustice but rather as providing development assistance for which so-called underdeveloped groups should be grateful.[77]

The increase of quotas for non-dominant groups erodes the protectionist advantage of China's largest cities, which contain the greatest number of elite universities. An oft-cited statistic is that the combined acceptance rate for China's top two universities, Tsinghua and Peking, both located in Beijing, is around 1 percent for residents of the capital city, whereas around only 1 out of 1,000 students from Shanghai and a mere few out of every 10,000 students from ordinary provinces can attend these universities.[78] But this relatively extreme example may be a poor index of overall fairness. More prosaically, between 4 and 5 percent of students in the provincial-level cities of Beijing, Shanghai, and Tianjin gain admission to Project 985 universities, whereas the admission rate to Project 985 universities hovers between 1 and 2 percent in ordinary provinces (Table 2).[79] The high admission rates of centrally located cities is often a result of distorted quotas that favor local residents. Thus, the quota system in China pulls both ways, providing both preferential treatment for the already privileged and modest positive policies for marginalized groups.[80]

When reforms in the mid-2010s resulted in moderate rollbacks of regional protectionism, parents in many large Chinese cities demonstrated, resulting in a rare display of middle-class protest, although arguably the citizens disadvantaged by such protectionism have more to protest about.[81] To a large degree, however, the issue of regional protectionism is a red herring: It draws attention away from local and sub-regional disparities which are even more dramatic but not as widely known. In "good" high schools in urban places, nearly all students go on to study in a first-tier university, a broader designation that includes the Project 985 institutions and Project 211 institutions. By contrast, the number who achieve this goal in ordinary, non-keypoint schools in the countryside or underperforming urban schools is often negligible, less than 1 percent if any.[82] Despite the expansion of higher education, the Gaokao remains a fierce competition for a small number of elite college seats. As people say, the test is like "a great army crossing a narrow-plank bridge"; many will fall off along the way (Figure 4).

If disparities in admission rates are so extreme, why do students nevertheless see the Gaokao as relatively fair? The answer is complex, involving at least three factors. First, although provincial-level protectionism is well-known and discussed widely in the media,

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[77] Of course, in other contexts of affirmative action, such as the United States, dominant social groups often also regard affirmative action, all rhetoric to the contrary, as a gift for which disadvantaged minorities should be grateful.
[78] Yiqin Fu, "China's Unfair College Admissions System," *The Atlantic*, 19 June 2013 <https://www.theatlantic.com/china/archive/2013/06/chinas-unfair-college-admissions-system/276995/>.
[79] Howlett 2021a, chapter 3.
[80] Minglang Zhou, "China's Positive and Preferential Policies," in *Affirmative Action in China and the U.S.: A Dialogue on Inequality and Minority Education*, ed. by Minglang Zhou and Ann Maxwell Hill (New York: Macmillan, 2010), pp. 47–70.
[81] D. Cohen and Beauchamp-Mustafaga, "Anti-Privilege Campaign Hits the Chinese Middle Class."
[82] Howlett, *Meritocracy and Its Discontents*, chapter 3.

local disparities are closely guarded secrets. Educational authorities treat admissions statistics as top secret, meaning that parents and even education researchers who want to gain an accurate picture of educational inequality must painstakingly assemble data from disparate sources. Second, because the Chinese education system is so stratified, the definition of success differs widely from place to place and school to school. For students in a peripheral rural high school, admission to any four-year university would be a coup, while for urbanites in a keypoint school success is minimally defined as admission to a Project 985 university. Finally, the remarkable individuals who rise from modest backgrounds to achieve extraordinary success help to breathe life into the myth of meritocracy. The number of these "dark horses" is not great, but their exploits are widely celebrated, which keeps hope alive.

The Emptiness of University Education

College students widely complain that university education is empty. To be sure, many college majors and programs in China, particularly at elite universities, provide excellent training. But students in ordinary universities often say that the knowledge their professors teach is out of date and disconnected with the realities of the employment market. In addition, students choose their major before attending college, usually not out of interest but because of practical considerations—for example, ease of admission or perceived quality of job prospects. Having toiled in monomaniacal fashion for twelve years to do well on the "final battle," the Gaokao, many young people have little conception of what they are interested in and find themselves locked into college majors that they do not enjoy pursuing. And whereas the Gaokao is a trial of merit, examinations in college count for little. Once students matriculate, they are virtually guaranteed to graduate. Only those who plan to pursue postgraduate education overseas must worry about performing well.[83] Employment is said to be determined not by one's grades but by the ranking of one's college and major, which is fixed upon matriculation. Since the college that one attends forms a static aspect of personhood, people ironically refer to it as their "birth status." In contrast to their hopeful expectation of the Gaokao, which they say can change fate, the college years seem devoid of fatefulness. They are hollow.

Since grades matter little and college courses often seem misaligned with the job market, many students spend their time in college preparing for further examinations, such as the national or provincial civil-service exams, the graduate-school entrance exam, or various tests required for study abroad. Other students pass their college years sojourning away from campus, working as migrant laborers in various temporary jobs only to return at the end of the semester to take their exams. Some start small businesses, selling products from their hometowns. Still others earn money as "substitute examinees" or "sharpshooters," helping people cheat on the Gaokao. Those who are less entrepreneurial often describe large portions of their college experience as "frittering away the time," a

[83] In addition, some students who earn top marks in college can receive guaranteed admission (*baosong*) to graduate school, but the numbers are relatively few.

description that includes playing video games, seeking amusement with friends, and chatting online.

Upon graduation, this feeling of emptiness may gradually transform into a more serious existential malaise. Most students have worked their whole lives with the expectation that a high score on the Gaokao will enable them to fulfill their parents' and grandparents' expectations of securing a good job and leading a stable, white-collar life. After college, however, many young people find themselves confronted with a disappointing reality. Graduates, especially of second- and third-tier universities, increasingly discover that the labor market will not reward them with jobs that can fulfill their parents' and relatives' dreams for prosperity and stability.[84]

Under China's slowing growth, even many students with a degree from a Project 985 university are having trouble finding jobs. A master's degree has almost become a prerequisite for a job, ratcheting up competition on the graduate school entrance exam to unprecedented proportions. Those without good "birth status" are even less lucky. Young college grads from second-rate schools, who are predominantly of rural origin, find themselves working as couriers, masseuses, or farmers after studying finance, marketing, or economics. The majority of college graduates now earn less than an average migrant worker.[85] The increase in graduate under- and unemployment means that the massification of higher education has exacerbated rural-urban income inequality despite expanding access to college.[86]

For these reasons, many college graduates in their twenties and thirties report experiencing a fundamental "disconnect between ideal and reality," which potentially presages growing discontent with China's established technocratic elite. Increasing numbers choose to quietly quit or "lie flat," and complaints of involution—escalating competition for inferior returns—have become rampant.[87]

In some respects, this widespread existential crisis is structural to the Chinese examination system as it functions in the post-1980s period of labor-market liberalization. The system was designed for an era when every college graduate was assigned a job. Thus people frequently speak of a corresponding disconnect—namely, that between the Gaokao and the labor market. In many ways, the Gaokao, with its admission quotas and central planning, is a holdover of the planned economy, whereas the labor market has largely already shifted to the invisible hand of supply and demand. It remains to be seen whether the current round of reforms to the Gaokao will help reconcile this contradiction.

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[84] Yanjie Huang, "China's Educated Underemployment." Mok and Wu, "Higher Education, Changing Labour Market and Social Mobility in the Era of Massification in China."
[85] Yanjie Huang, "China's Educated Underemployment."
[86] Mok and Wu, "Higher Education, Changing Labour Market and Social Mobility in the Era of Massification in China."
[87] Chen, "These Chinese Millennials Are 'Chilling,' and Beijing Isn't Happy" *New York Times*, July 3, 2021. Q. Wang and Ge, "How One Obscure Word Captures Urban China's Unhappiness."

But there are grounds for skepticism. Despite the expansion of higher education since the 2000s, the Chinese educational system remains focused on making fine distinctions between the abilities of different test-takers rather than providing broad-based and high-quality educational opportunities to all. This system excels at providing distinction to elites in the form of top educational credentials, and until recently has also effectively pulled large segments of the population into the educational gyroscope of meritocratic competition, which reinforces state legitimacy. The country has also poured massive amounts of resources into its top research institutions. But it does not seem to be successfully pivoting to providing the kind of broad-based, high-quality education at every level that will help it escape the middle-income trap. China's investment in education as a percentage of GDP remains relatively low at 3.6 percent (for comparison the U.S. invests 6.1 percent of GDP in education).[88] Because only about half of young people go the academic route and take the Gaokao, a key investment area is vocational education. But despite increasing investment in vocational training, these programs largely remain of low quality, stymied by the perception that anyone who participates in them is a failure.[89]

Expanding access to high-quality formal education is not the only key to solving China's human capital crisis. Many people in China embrace a deep ethic of entrepreneurialism, driven by a cultural preference for starting one's own business over working for others. People of rural origin are eager to learn new knowledge and to take every opportunity, formal and informal, to improve their skills and capacities. By pursuing economic liberalization and financial reform that would make it easier for people of rural origin to access credit and start businesses, the country could help to unleash this entrepreneurial energy, which was so key to its rapidest period of poverty reduction in the 1980s.

Conclusion: Meritocracy and Its Discontents

Without doubt, the story of education in modern China has been one of a "silent revolution."[90] In the twentieth century and particularly after the introduction of the Gaokao system in 1952, the competition for meritocratic credentials has become increasingly open to wider groups who had rarely or never before competed in the Chinese meritocracy: women, disadvantaged ethnic minorities, and ordinary farmers and workers. But an open competition does not mean an open elite.

To be sure, the composition of the elite has shifted several times over the past hundred years and the numbers of elite degree holders has also increased, although perhaps not as

[88] I take these figures from World Bank data: <https://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS?locations=CN>.
[89] Rozelle and Hell, *Invisible China*; Woronov, *Classwork*.
[90] Chen Liang and others, "Wusheng de geming: Beijing daxue yu Suzhou daxue shehui laiyuan yanjiu, 1952–2002 (Silent revolution: The origins of Peking University and Soochow University undergraduates, 1952–2002)', *Zhongguo shehui kexue*, 1 (2012), 101–21.

much as people imagine.[91] And the Gaokao, which reinforces a cultural belief in the fate-transforming power of diligence, probably does more to promote social mobility than college-entrance systems in many other countries, such as the United States.[92] Although people in the U.S. believe in the meritocratic value of hard work, athletic competitions, rather than academic ones, seem to be the most important fateful rite of passage for promoting this virtue in the United States. Many Americans believe that athletic talent is trainable whereas academic ability is more completely determined by what are believed to be intrinsic capacities such as IQ.[93] The relatively great faith in diligence of people in China may have important lessons for education systems elsewhere.

But the most touted successes of the Chinese system come from large urban centers like Shanghai, which are not representative of the country as a whole.[94] The Chinese education system remains extremely stratified and is becoming increasingly so as social inequality grows. The current definition of elite success, admission to a Project 985 college, is a vanishingly rare accomplishment among people of underprivileged backgrounds. Now as before, the exam system in China, rather than providing an open door to the disadvantaged, is a tool of elite social closure: It mainly serves to certify the status of people who have already accumulated enough social, economic, and cultural capital to compete.

One can reasonably ask if the best interests of society are served by such a system, which provides only a narrow segment of the population with the conditions that they need to reach their full academic potential. Of course, people of rural origin, even if they lack educational opportunity, at least have the normative expectation that they can use diligence to "transform fate." But without doubt, the education system fails to unlock the full potential of rural residents and of groups perceived to be less capable of excelling in math and sciences: women and ethnic minorities.

Yet people in China often push back against such critiques. They say that in a country with such a large population and so few spaces at the top, it is necessary to have a strong sorting mechanism. In addition to giving ordinary people hope, the Gaokao, such supporters say, encourages them to "come to terms with fate." And even people who

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[91] According to Benjamin Elman, one in 540 people in China possessed an elite degree in late Qing China. See *Civil Examinations and Meritocracy in Late Imperial China*, p. 106. Remarkably, this figure is on the same order of magnitude as elite university degree holders in China today: Today less than 1 percent of China's children achieve admission to a Project 985 university, the current hallmark of elite success.
[92] Liang and others, "Wusheng de geming."
[93] Lenora Chu, *Little Soldiers: An American Boy, a Chinese School, and the Global Race to Achieve* (New York, NY: Harper Collins, 2017). Chu draws on the work of psychologist James Sigler to make this point. See, for example, Harold W. Stevenson and James W. Stigler, *The Learning Gap: Why Our Schools Are Failing and What We Can Learn from Japanese and Chinese Education* (New York: Summit Books, 1992). Of course, Americans are far from monolithic. In particular, the "model minority" of Asian Americans routinely outperforms other ethnic groups, probably in part due to a greater faith in academic diligence.
[94] See Tom Loveless, "The Children PISA Ignores in China," *The Brookings Institution* (2019) <https://www.brookings.edu/blog/brown-center-chalkboard/2019/12/19/the-children-pisa-ignores-in-china/>. See also Tom Loveless, "Lessons from the PISA-Shanghai Controversy," *The Brookings Institution* (2014) <http://www.brookings.edu/research/reports/2014/03/18-pisa-shanghai-loveless>.

believe in making a more open and diverse meritocracy still see the Gaokao as performing some useful social functions. True, the focus of the exam on rote memorization does little to encourage creativity.[95] But the examination is a fateful rite of passage in which people personify high cultural virtues: discipline, grit, composure, luck, quality, and filial devotion.

The architects of the Gaokao face a momentous challenge. If the exam is to continue to serve as a fateful rite of passage, then people must perceive it as both consequential and fair. But many in China's poor rural areas no longer see the Gaokao as providing a real opportunity for mobility. In response, students are dropping out of school; some even become possessed by spirits or join rebellious millenarian groups.[96]

Simultaneously, many in the middle classes no longer perceive the examination as an accurate test of quality and thus dispute its importance. Many members of this relatively privileged group are voting with their feet, sending their children to be educated abroad. A significant number are "Gaokao refugees" who underperform in the Chinese education system. Until recently, however, they have largely seen China as the land of opportunity. Since 2013 around 80 percent have returned home.[97] But disillusionment is now growing with China's slowing growth and the Xi Jinping administration's illiberal policies. This dissatisfaction has spiked in the wake of his draconian pandemic controls and perceived mishandling of the exit from the pandemic. As more educated middle-class people in China prepare to "run," rising numbers of top students may go abroad and the percentage of study-abroad returnees may plummet.[98]

The challenge of maintaining the fatefulness of the Gaokao is not one that is intrinsic to the examination system alone but involves many social and political problems beyond the school gates. Nor is China the only country that faces this kind of challenge. Examination-based meritocracy has become a hallmark of modern society. Many countries now use some form of open, anonymous, competitive examination to cultivate and select their governing classes. But like their counterparts elsewhere, Chinese state leaders are confronting economic and social challenges that may yet undermine some basic premises of educational meritocracy, including stagnating economic growth and increasing inequality. Educated un- and underemployment in China is already high and

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[95] However, the role of foundational knowledge in creativity is often underestimated. See Lenora Chu's discussion in *Little Soldiers*.

[96] Howlett, *Meritocracy and Its Discontents*, chapter 6 and conclusion.

[97] From 2007 to 2017, the number of Chinese college and postgraduate students studying abroad more than quadrupled from 140,000 to 610,000, with more than half studying in the United States. For China figures, see Center for China and Globalization (CCG), *Report on Employment & Entrepreneurship of Chinese Returnees* (Center for China and Globalization, 2017) < http://en.ccg.org.cn/wp-content/uploads/2017/08/Report-on-Employment-Entrepreneurship-of-Chinese-Returnees-2017.pdf >. For U.S. figures, refer to "Open Doors | Institute of International Education" <http://www.iie.org/Research-and-Publications/Open-Doors>. In addition, many relatively unprivileged students of urban background also study abroad if they cannot succeed on the Gaokao. See Vanessa L. Fong, *Paradise Redefined: Transnational Chinese Students and the Quest for Flexible Citizenship in the Developed World* (Stanford, CA: Stanford University Press, 2011).

[98] Yuan, "'The Last Generation.'"

may rise much further in the age of automation, economic transformation, and mass education. By loosening the perceived relationship between academic accomplishment and social success, the difficulty college graduates face in finding good jobs hollows out the promise of meritocracy. Facing the realities of slowing economic growth what they term an uncertain political macro-environment, many people in China will choose to "run" by emigrating to foreign countries.

It will be in the U.S.'s long-term advantage to welcome these young people, who largely maintain a positive image of the United States as a land of opportunity, freedom, and democracy. At the same time, the U.S. should continue the cultural exchanges that have reinforced these positive views. Generations of Chinese scholars and students have visited or studied in the U.S. Such exchanges counteract Chinese propaganda and help give Americans a window into social and political developments in China. These interactions are even more important in an era when it is increasingly difficult for Americans to travel to China for in-person research. For these reasons, I recommend fully restoring the China Fulbright exchange program, which was suspended in July 2020.

In the longer term, not only China but countries everywhere including the U.S. face fundamental challenges to their systems of meritocracy. The silver tsunami of social aging is washing over not only China but the whole world except for Africa. This demographic shift represents a fundamental change in political economics. Increasingly, countries will focus their economies on taking care of the very old, and the elderly may assume increasing political and economic power. Countries that are friendly to immigration, like the U.S., will have an advantage, whereas those that are culturally averse to immigration, like China, may find themselves flatfooted. Another challenge is automation. Artificial intelligence systems such as ChatGPT show that not only blue-collar labor but high-skilled creative and technical jobs can be automated. The old way of approaching automation was to focus on retraining workers for new jobs. But as increasing domains of work can be replaced by AI, the problem is unlikely to be solved by continual upskilling. At the same time, although inequality is decreasing between countries, it is increasing within them all over the world as narrower segments of the population accumulate greater wealth.[99] Such developments are leading to "involution" not only in China but in many places. Under such conditions, the middle classes become increasingly anxious about losing their social position and the poor see no chance of breaking into the elite.

A time-honored and proven solution to encouraging social mobility is affordable or free access to high-quality education. But if hard work no longer guarantees success—and, indeed, if the very social system in which such a statement is intelligible ceases to exist—then mass meritocratic competitions such as the Gaokao may no longer be meaningful. New solutions, such as redefining work and instituting universal basic income, may be required.

[99] Milanović, *Global Inequality.*

Figures and Tables

Figure 1: Students in the countryside of Fujian Province studying diligently for the "final battle," the Gaokao. Photograph by author.

Figure 2: A mock-up of imperial era examination-hall cubicles. This style of cubicle was in use from the advent of open, anonymous, competitive civil exams in 960 CE until their abolishment in 1905. Note the strikingly modern construction, which resembles modern school desks, prison cells, or office cubicles.

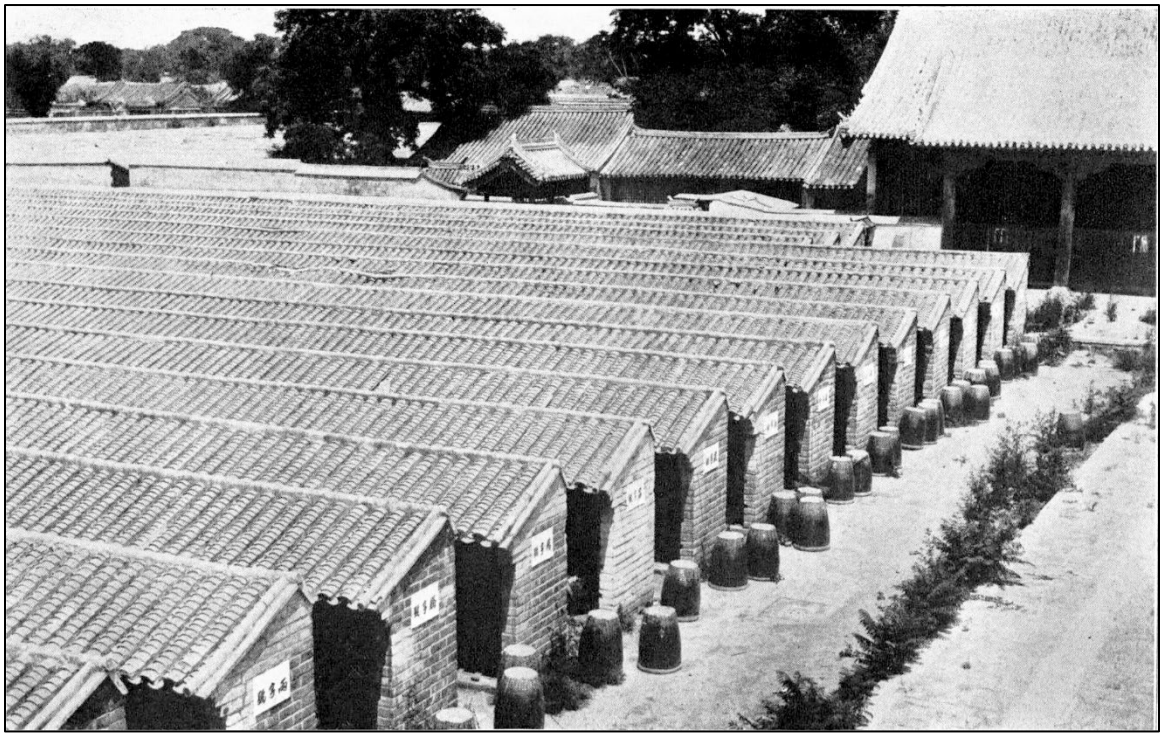

Figure 3: The imperial examination compound in Beijing, circa 1899. The exam-hall cubicles were arranged in neat rows like modern army barracks. Source: Conger, Sarah Pike. *Letters from China: With Particular Reference to the Empress Dowager and the Women of China*. Chicago: A. C. McClurg & Co., 1909, 56–57.

Figure 4: “A great army crossing a narrow plank bridge.” The sign on the desk at the end of the bridge reads “Prestigious Schools Admissions.” Cartoon by Ensheng Han.

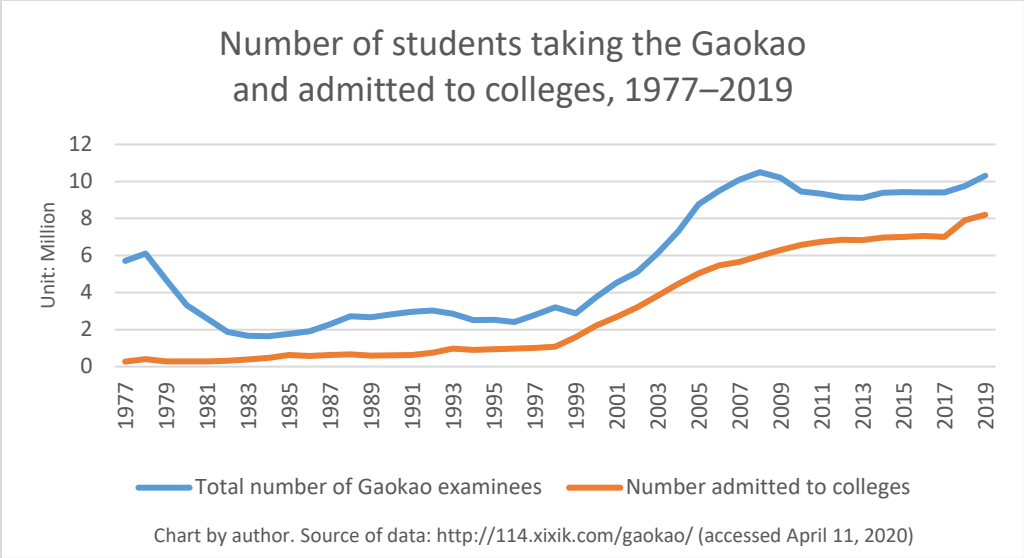

Table 1: Following an initial surge due to pent-up demand while the exam was suspended during the Cultural Revolution (1966–76), the number of Gaokao examinees has steadily risen in the reform era (1976–present), accelerating dramatically in the late 1990s due to higher education expansion. Although the proportion of examinees admitted to all colleges has grown (it was nearly 80 percent in 2019), the numbers admitted to elite Project 985 universities remains low, under 2 percent in most provinces.

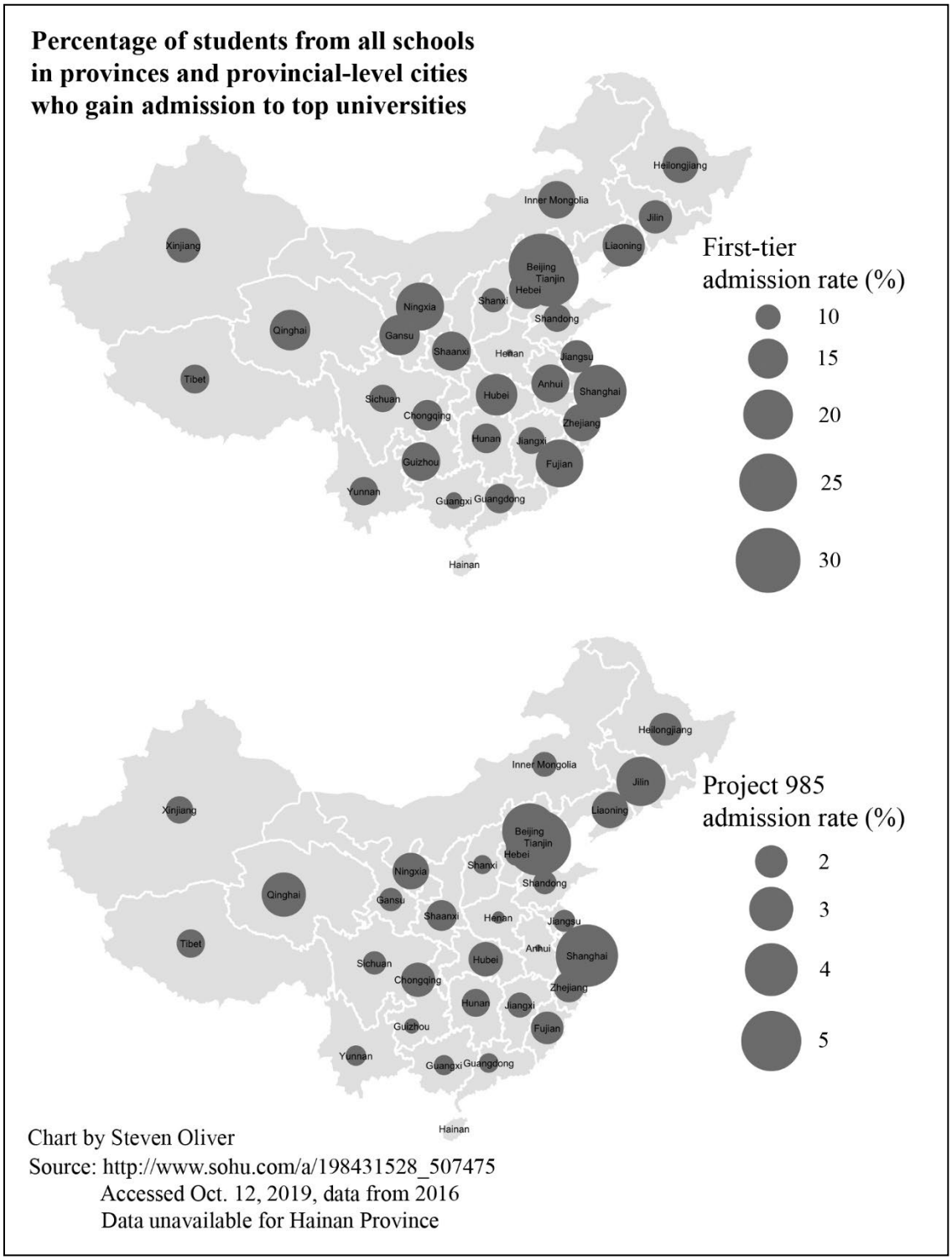
Percentage of students from all schools in provinces and provincial-level cities who gain admission to top universities
Heilongjiang
Inner Mongolia
Jilin
Liaoning
Xinjiang
Beijing
Tianjin
Hebei
Shanxi
Ningxia
Shandong
Qinghai
Gansu
Shaanxi
Henan
Jiangsu
Tibet
Anhui
Shanghai
Sichuan
Hubei
Chongqing
Zhejiang
Hunan
Jiangxi
Guizhou
Fujian
Yunnan
Guangxi
Guangdong
Hainan
First-tier admission rate (%)
10
15
20
25
30
Heilongjiang
Inner Mongolia
Jilin
Liaoning
Xinjiang
Beijing
Tianjin
Hebei
Shanxi
Ningxia
Shandong
Qinghai
Gansu
Shaanxi
Henan
Jiangsu
Tibet
Anhui
Shanghai
Sichuan
Hubei
Chongqing
Zhejiang
Hunan
Jiangxi
Guizhou
Fujian
Yunnan
Guangxi
Guangdong
Hainan
Project 985 admission rate (%)
2
3
4
5
Chart by Steven Oliver
Source: http://www.sohu.com/a/198431528_507475
Accessed Oct. 12, 2019, data from 2016
Data unavailable for Hainan Province

Table 2

PANEL I QUESTION AND ANSWER

COMMISSIONER PRICE: Thank you all for your excellent testimony. We are going to call on the Commissioners in reverse alphabetical order. So I will start with Vice Chairman Wong.

VICE CHAIRMAN WONG: Thanks, Reva. Good morning, thanks for your testimony. A couple of questions, and forgive my ignorance or the rudimentary nature of my questions, but I'm going to ask them anyway.

First of all, a number of you lay out the kind of testing or meritocratic system, either at the secondary school level or the higher education level with the testing China. What role though, throughout the pre-higher education in the educational system, does corruption play as far as between students, or parents of students, and teachers? What effect does that have on the quality of the schooling?

I'm not sure if there's any kind of statistical or hard data you could present, or something anecdotal. But I'm just curious what role corruption plays. Maybe, yeah, Mr. --

DR. LOYALKA: Anecdotally, having lived in China for a long time as well, it is true that parents have this habit of giving gifts to teachers so that they will treat their child better in school. That's pretty ubiquitous across China, even starting from kindergarten going all the way through high school.

I think in recent years there's been an attempt to clamp down on that. But I would be surprised if that's been diminished significantly.

Another more formal kind of channel that's not corruption, per se, but it's kind of surprising maybe when we think about meritocracy, is that for academic high schools there is basically two cutoffs to getting into a particular academic high school. There's one that's the regular cutoff. If you score high enough, you get to go to that elite academic high school, or whatever it is. But if you don't score high enough, there's another cutoff where you can pay extra money to be able to go. And it's quite a sizable amount.

And so that allows people that aren't doing as well but who have more money to be able to go to academic high school and therefore access college.

VICE CHAIRMAN WONG: And what overall effect, and is it significant, does this corruption or this non-meritocratic system have on the educational system in China?

DR. LOYALKA: For the first, there's not a lot of empirical data, as you can imagine, on trying to measure the impact of parents giving gifts to teachers and how that results in student's performing differently.

For the second, we can say that it makes a sizeable difference in who can go to high school and who can go to college in China. We have a paper about that. I'll have to go and look at the exact numbers, but it's a significant change in allowing people who are economically more advantaged to be able to go.

DR. ROZELLE: Could I just add one thing? So in these rural areas, they don't have the resources to give these gifts to teachers. And so the really good teachers want to shift to urban schools where they get the gifts. And so it contributes to the decline in quality of these rural schools.

DR. HOWLETT: I had a couple of points. One is that the factors that Dr. Loyalka and Dr. Rozelle have talked about raise the importance of the Gaokao college entrance exam as a relatively incorruptible exam. So that's an exam where it's very difficult or impossible to spend money or bribe one's way into a better college through the exam directly.

And there's a lot of things one can do leading up to the exam, but the exam itself is considered incorruptible, and it's relatively closely policed. There are ways to cheat on the exam by hiring a sharpshooter, or someone to take the exam for you. But it's difficult to do.

And the other point I'd like to raise is just that there is an increasing number of private schools in China. And they are also sapping rural areas of teachers, because they can pay a higher salary. They get some of the best students from the countryside by giving them scholarships.

And this further sort of hollows out the rural public education system by creating a brain drain effect, in addition to the normal brain drain that you're getting from people wanting to migrate to urban areas.

VICE CHAIRMAN WONG: And, Dr. Howlett, it's your view that both the high school entrance exam and the higher education entrance exam, they are relatively unaffected by Party influence. So if your child or if you are a high level Party official, whatever, at the provincial level or national level, you can't affect the results?

DR. HOWLETT: I think my, and this is anecdotal, but my sense on the college entrance exam is that it's not possible for people to corrupt that exam, even with a lot of influence.

However, there are a lot of things leading up to the exam. So for instance, the best students in every high school that are relatively well resourced–so these are urban high schools mainly–these urban high schools get a quota of students that they can just send to colleges. And that's through a preferential admissions program.

And it used to be that principals would do favors to their friends by selecting students with good relationships or good favorable connections for those preferential admissions.

A lot of schools, when there was pushback on this, shifted to just selecting students who had the best test scores. But the list of students who would be in that list of students who could be considered, there was some maneuvering there.

So there's still a little bit of maneuvering. But the interesting thing about that is that the purpose of these preferential admissions policies were to create or to give a pathway to college for students who may not do really well on examinations but were innovators or creative. And that whole purpose is kind of pushed aside.

VICE CHAIRMAN WONG: Thank you. I'm out of time, but I may have a follow-up question.

COMMISSIONER PRICE: Thank you. And after we go through the panel and those panelists who are joining us virtually, we'll come back to more questions if we have time.

Commissioner Wessel?

COMMISSIONER WESSEL: Thank you to our witnesses for great testimony. Thank you also to the Chair and Vice-Chair. You know, this is a really important hearing. You know, the headlines these days are about the surveillance capabilities of balloons, et cetera, and not the capabilities of the Chinese people, and what challenges and opportunities that poses.

And this hearing is a long time coming. We've examined the capabilities of Chinese military troops, training regimes, et cetera, but have not done enough or anything in this area. So thank you for the hearing today.

I want to ask a couple of questions that came up as you were talking. And first, Dr. Rozelle, with regard to the inadequate attention to rural education, and from what I've heard as well, not enough resources being applied throughout the system, is any of that designed to advance the power of the CCP over its own people?

Is there a tension between education and reform, rights, you know, et cetera? So is there a limit to how much educational opportunities will be provided for how it might empower the thought processes and interest the people?

And, Dr. Rozelle, after you, but if each of the other witness has a comment on that.

DR. ROZELLE: Sure, that's a really good question. And we've thought a lot about it. I think the answer is no. So number one, as Prashant said, and as I had a phrase, but there's more in the written testimony, the government has put a lot more effort into the rural education system.

And I was going to ask, does the government know about these problems you're talking about? And the answer is I think yes. And I think that they don't do the right thing of investing in zero to three.

But the problem is, their education system is very much like ours. It's very decentralized. 40,000 school districts in China, we have 40,000 school districts here. Our school districts are funded by property taxes mainly, some from above. Theirs are from local taxes and some from above, more from above. And so that's been the basic -- So these rural areas were poor to start with, they have low tax bases. So they just have very poor facilities. And I think that -- I don't think they want those rural people to be downtrodden, you know, unable to participate. So they end up in these factories.

Like he said, the factories are automating at a very rapid pace. And, you know, they see this rural economy as sort of a weak spot in future growth. And I'll leave it there. That's a great question though.

COMMISSIONER WESSEL: Dr. Loyalka?

DR. LOYALKA: Thank you. Yeah, I was essentially agree. I think in addition to mentioning the decentralization of China's education system in provinces and localities, it's also important to realize that the central government isn't a monolith either. I think that there are differences between ministries in terms of how capably and effectively they manage the education system.

And I would think that overall the central government has a really positive view to try and improve rural education and rural development. But there are agencies that seem to get in the way of that, just because of capacity and self-interest.

COMMISSIONER WESSEL: Dr. Howlett?

DR. HOWLETT: Thanks. I would add a point that in the STEM field, so in science, technology, engineering, and mathematics, I think China wants their students to be very -- and China's not a monolith, but as a shorthand -- the state wants the students to be very creative and very proficient.

Humanities, I think, is -- and history, and that kind of thing -- is another thing. And in Chinese high schools -- I'm a social anthropologist, so I spend a lot of time in Chinese high schools doing field work and observing classes. And so what students say and what teachers say is that humanities, and history, and geography, these are things you memorize. And you memorize to pass the test.

And this is norm reference exam that is very good at making fine distinctions between different people and ranking them. It's not good at testing whether or not people achieve a certain level of proficiency or skill.

And what students would say, in particular with regards to humanities, if you love humanities, don't become a humanities major in China, because it's all about memorization.

So I think, in terms of educating a critical population that could question national orthodoxies, I don't think that the exam system is geared to do that, nor do I think anyone in the Chinese system is really pushing for that at the policy level.

VICE CHAIRMAN WONG: Thank you.

COMMISSIONER PRICE: Commissioner Schriver?

COMMISSIONER SCHRIVER: Thank you, Madam Chair. Thank you to our witnesses for the excellent statements and expertise you're contributing to this. This is very interesting for me as well, a topic I haven't looked a lot at. And I found myself sort of oddly reassured and sort of feeling cold-hearted about it, like, good, China's failing more of its young people than we are.

But it's, you know, it does all relate to the things that we care about at the high level in terms of competition. So this is something we need to understand better.

I guess Dr. Rozelle to start, what to you, in this very overwhelming problem they have, with the decentralized system and huge numbers of children in the rural areas, what to you would say, now the CCP, the state Party, is serious, that not only do they understand the problem and they don't want to trap people, and I thought that was an excellent question, but now they're serious. And then we have to be mindful of how that trickles up to higher level education.

DR. ROZELLE: Yeah, another good question that we think about and we are looking at, and I think what you would really want to see is two things. First is a shift of priorities to try to take these rural kids from rural areas and get them into urban schools. So allowing migration, reducing the importance of the house, the Hukou, the residency system, permit system, right? Because that's where you're going to get good teachers and more focused education.

There is effort at that. Now, it's done in an area that's -- they're letting them move from the rural areas to the local county seats. So think about that as in central Iowa, you know, moving from a farm into the local county seat, which is improvement, yes. But it's probably not going to be there for long. So that's one thing.

The other thing is they really need to do what all these other middle-income countries are doing, recognizing that they have a problem that starts at zero to three. You know, parents want their kids to go to college, 95 percent of rural parents want their kids to go to college. By junior high, they're dropping out.

For 5,000 years they raised a farmer, now they've got to raise a college student. And they just don't know. And so I think it's those two efforts. And it's going to be -- that's going to require a big shift of resources. I say take it from other parts of the economy and put it in there. And when we see that, they may be serious.

DR. LOYALKA: Yeah, I agree with what Dr. Rozelle said. I would just add, you know, it's important to recognize that rural China isn't doing badly. Like, when you think of it's such a large number of school children and the amount of resources they're putting in.

Our surveys show that students are learning math skills in seventh and eighth and ninth grade which is, you know, really surprising. Because in a lot of developing country contexts they're not.

Just to say that China has been doing significant things in the last 10–15 years, to really invest in rural education. I mean, if you go to, you know, poor rural area you look at the school buildings, they're tremendous. The teachers are qualified, they show up to school, they show up to class. The curriculum is good, and there's this motivation to try to, you know, pass the high school entrance exam.

So just to say that the things that Scott said, which I think are really important, but there's also a lot that's happening that's not bad.

DR. HOWLETT: I would add that, as Dr. Loyalka said, there's a lot of investment in rural schools. And I did some of my field work in a rural school in a county seat, a senior high school in Fujian Province, a relatively wealthy coastal province. And they had a new school building, and they had done a bunch of local county investment to make scientific laboratories, a new library, and a lot of things. And they had done this in order to get a state accreditation of a higher-level school. And there's a ranking system that's brought them up in the rankings.

But as soon as the inspectors were gone, those laboratories were sort of taped off and students weren't allowed to go in there. And the focus was back on passing the college entrance exam. And one can understand why. This is how students from rural areas change their fate. So there's a lot of emphasis on quality education and on creativity and innovation. But how it filters down to rural areas is questionable.

COMMISSIONER SCHRIVER: Thank you. I might jump in on a second round.

COMMISSIONER PRICE: Okay, seems that my name is next in reverse alphabetical order. In a 2015 Congressional trip to China, including a stop at the University in Lhasa, in Tibet, the party secretary of the university mentioned to the members of Congress that to them modern education accompanies re-education in the TAR, in the Tibet Autonomous Region.

And it brings to mind, as I think about that comment, when we talk about meritocracy, when we talk about the college entrance exams, how is it weighted in terms of the STEM field versus the humanities field, the parts of the education that are going to contribute to the state versus contribute -- or the state indoctrination, or states way of looking at things, as opposed to the science fields and the innovation that might come from that? And that's to anyone who wants to jump in.

DR. LOYALKA: This is not great, because I have to say in recent years I don't know. I do know that there's been a lot more emphasis on studying political doctrine and that kind of thing. But I do think that the majority of the weight is on learning the technical subject matter, so math and science, and the different types of science.

I do agree with my colleague that I think that the humanities is a lot of rote-kind of memorization. And it's within that that you have ideology placed, or certain world views placed.

But I do think that the students that are going through high school, first of all, they get to choose whether they want to go into the STEM field or not. But as they go through, they are primarily learning STEM subjects and so forth.

DR. ROZELLE: Let me just say, to answer another part of your question, there's a very interesting paper written by a professor in the Ivy League. And he looks at the feelings of students towards the state and towards the international issues, relations with the United States being one of them.

And before and after a reform of the curriculum that was in the mid-2000s, there's a real difference in how kids look at the state. And I think that's important. When they get to high school, they do math and science. And they're getting ready for the college entrance exam.

But all through elementary school, there is an emphasis on, you know, the party, the state, your role in that. And so I think that that's been a change, and trying to address the question you asked.

DR. HOWLETT: Well, we know that under

Xi Jinping there's been increasing emphasis on teaching Xi Jinping Thought and political correctness in schools. But politics and ideology, which is a course in high school, is not a required subject on the college entrance examination.

I think Tibet and Xinjiang are special cases in the sense that there's going to be a lot of emphasis on political indoctrination in those places and, of course, there is all over China.

But in my personal experience sort of on the ground, empirically, anecdotally, from observing classes -- I mentioned in my written testimony, for example, that when I was in a politics class in my rural field site, a student got a politics quiz back that he'd gotten a bad grade on. And he kind of looked back at me and snickered and said, "socialist brainwashing."

And so I think that sentiment is widespread. These are things that people memorize to pass tests. And I think that -- Similarly, things like the weekly flag raising ceremony, or other kinds of patriotic education, teachers widely acknowledge that this was empty, this is something that was performative, students didn't really buy into it.

So there is something deeper about nationalist history and things like that, that can come through the family, and come though popular media. And when that overlaps what happens in the school it sticks.

But I think that the lessons, as I mentioned in my testimony, that school teaches kids in terms of political lessons are much deeper and has to do with national development and wanting to move from a rural area to an urban area. And when one's merit has been recognized by the state through this examination system, then one tends to also recognize the state as legitimate.

COMMISSIONER PRICE: Thank you all. I'll save my second question for a second round if we have one. I'm going to turn to Commissioner Helberg, who is joining us remotely. This is his first hearing, so welcome.

COMMISSIONER HELBERG: Thank you so much, Commissioner Price and Commissioner Cleveland and thank you to the witnesses for participating today. Your testimonies have been very helpful. Mr. Loyalka and Mr. Rozelle, both of your testimony highlight the deficiencies of China's educational system. Mr. Loyalka, your testimony even mentioned during college, students appear to learn very little in terms of academic skills and higher order thinking. At the same time, China outperforms the U.S. and the world on so many innovation metrics and outcomes. China has the world's highest number of researchers, the world's highest number of STEM PhD's, the most patent applications. It spends 2.1 percent of its GDP on R&D and has made billions of investments in strategic sectors to great effects. Their achievements and more importantly their outcomes in AI networking technologies, EV technology, and hypersonics speak for themselves. How do you both explain this discrepancy, and if the education system is truly, quote, "empty," are these achievements driven by its diaspora and IP theft practices? And lastly, are either of you aware of any precedent of a country moving to the outer edge frontier of the technological edge all the while remaining middle-income. Thank you.

DR. LOYALKA: That's a great question. And it's, I think, multifaceted in terms of how we need to think about it.

First of all, we can remember that students that go through academic high school, and it's a large number of students, are doing really, really well in math and science and reading. In fact, they're doing so well that they start years ahead of students in Russia and India, and the United States, most likely, in terms of their skill levels. We did a cross-national study with nationally representative samples that shows this.

It's true that during college, students don't learn very much in terms of their basic academic skills and critical thinking. I think they learn some major specific skills, what our tests show. But I think that's because college is this place where they've taken the national entrance exams to get into college, and they kind of relax.

And I think it's when they go into the workforce, and they go into research institutes of the government, they go into companies, they stay at universities, that's where they can get into the opportunities to do exciting research and to really increase their skills on the job.

I would just add that China pours a lot of money into research in universities and into research institutes. I don't have the figures, but I think you mentioned some of them.

So I think it's just really important to realize that that's a parallel thing to look at which is not just what's happening in education but what's happening to support to research through educational institutions and through other institutions in the country.

DR. ROZELLE: I absolutely, totally agree with exactly what Prashant said. I'm old enough to have gone to college in the '70s and grad school in the '80s and remember the rise of Japan. And they were at the cutting edge of technology, and they were going to overtake America. And, you know, the relationship wasn't the same as that of our relationship now with China. But it was a huge concern.

And what we found out Japan did was they invested enormous amounts of money into electronics, into chemicals, into cars, automobiles. But they didn't have this economy -- There's 92 industries and sub-industries in economy that all have to grow when you go from middle-income to high income at two to three percent a year. And that's what undermined Japans' economy. They haven't grown since 1990s, right.

And I think that some of that is what we're seeing in China today. They're trying to plan these -- I mean, they put enormous amounts of resources into these few industries. And they make breakthroughs, because they have smart people, and they copy technology from the West, you know, et cetera, et cetera.

So I'm leaving it there. But I think that there's -- we need to consider those parallels. And they're good, and bad, and ugly, right.

DR. HOWLETT: I'd just supplement those important points by saying that I concur with Dr. Loyalka's views that higher education is largely what students refer to as sort of an empty experience after the fatefulness of the college entrance exam.

However, it's a very hierarchical system. And it was mentioned there is a tremendous amount of investment into the top universities. And I think the experiences of students at Peking University or Tsinghua University will be, you know, night and day different from those at second or third tier institutions.

COMMISSIONER PRICE: Thank you all. We're going to move on to Commissioner Goodwin.

COMMISSIONER GOODWIN: Thank you, Madam Chair, my appreciation to the witnesses. Dr. Howlett, I had a question about some of the reforms to the high-level exam that you referenced in your testimony, and -- performance to the college admission process itself to emphasize creativity, and innovation, and how those reforms disproportionately impact people of rural background.

But you also alluded to the fact that some colleges are actually administering their own special admissions exam and admissions process. How much latitude do the institutions of higher education in China have to administer their own exams, and how prevalent is that?

DR. HOWLETT: So there are many top institutions in China that administer their own examinations. But these are not a separate pathway into those institutions. They are exams that students take to get bonus points on the college entrance exam. And there are special pathways, as I mentioned earlier, preferential admissions for students to get into those colleges.

In general, as you mentioned, the increasing emphasis on what people in China call quality, or general creativity, innovation, comes at the cost of the fairness of the exam or the perceived fairness for people in rural areas. So things like having short answers on the exam that are sort of open-ended and cannot be memorized, this is perceived as undermining that fairness.

So I heard a policymaker/education researcher in China describe the exam as a balloon. You push on one side and it pops out, something pops out. And it's a very complex policy environment, and there's a lot of regional variation.

Until the mid-2010's the exam had been designed and developed under provinces. And provinces were then sort of incubators for innovation in the education system which is something that China does very successfully, as it tries to have different provinces incubate different kind of innovative approaches.

But under Xi Jinping, there's been a large re-centralization of the exam design to emphasize fairness. Because there were processes by which, if you went to a very good high school and your teacher was involved in making the exam, then, you know, you could get some sort of benefits from being taught by someone who was actually going to be making the exam. So there's been a re-centralization to emphasize fairness.

So there's always this push and pull between fairness for rural people and trying to increase innovation and creativity in the education system.

COMMISSIONER GOODWIN: But that touches a little bit of my follow-up question. I was fascinated after reading your testimony about the lasting faith in the system, despite the disproportionate impact and increasing challenges facing rural students, high unemployment among 18 to 24-year-olds, and so forth. And you touched on it a little bit there.

What's the impact of these changes for enhanced emphasis on creativity and innovation in colleges having their own exams, not in lieu of the high-level exam, but provide bonus points and so forth? Do you see that undermining this broad based and lasting faith in the high-level exam?

DR. HOWLETT: It's a push and pull. And I would nuance my short oral testimony by saying, you know, every year there's an increasing number of students taking the Gaokao, or the high-level exam. It's up above 10 million now. And I think that there is a tremendous amount of residual remaining faith in the exam. And there's always going to be this push and pull that we just described.

But I think a key word now in China is this word involution, or neijuan. And that describes escalating social competition for diminishing gains. So there's a sense that, among China's youth right now, that you take all these exams, you get into college. That wasn't good enough to get a job. Now you need to take a master's degree. There is this degree inflation, there's quiet quitting, or what they call lying flat, tang ping.

So there's sort of a broad sense that goes beyond this push and pull between innovation and fairness. There is a broad sense that it's getting harder and harder to succeed in this meritocratic environment.

COMMISSIONER GOODWIN: Very quickly, you also mentioned the growth of private institutions. Now are those secondary level or is there also a growth of higher education private institutions?

DR. HOWLETT: There are both. And I think -- there are both. But in the higher education, it's a very small part of the market. Mainly in senior high schools, that's where we see this sort of sapping of resources from public schools in the countryside, at least in the areas where I worked.

COMMISSIONER GOODWIN: Thank you.

COMMISSIONER PRICE: Okay, we're going to turn to Commissioner Friedberg, who also joins us remotely.

COMMISSIONER FRIEDBERG: Thank you very much. And thanks to all of our witnesses for really fascinating testimony.

I wanted to start with Professor Rozelle. To what extent are the problems that have emerged in rural education the result of deficits in early childhood learning education? To what extent is the problem the result of the fact that so many parents are migrant workers, and travel, and are away from home, and are not present to stimulate and help to educate their children at a very young age?

DR. ROZELLE: That's my area of research. And what we find, if you go into schools, and you test for their cognitive development -- you're not supposed to say in China the word IQ, but you test for their IQ. And then you test for their math test scores. It's a 45 degree line.

So Prashant keeps saying they're learning. And they are learning, because they push -- and the families want them to learn. But they learn from a very low level. And they learn little.

And if you take what we've done, these big studies where you take the difference in math scores within classes across and -- 60 to 70 percent of that is due to just low levels of cognitive development, delays within the classroom.

And so I think it's very, very important. And it also has to do -- did you go to a good pre-school, did your parents leave you behind with grandma? And all those are important factors, but they're much smaller factors.

I think the biggest cause and effect is the fact that moms and dads leave kids when they're zero to three, because they can't take their kids to the urban areas while they're working. And so these are all inter-tied.

COMMISSIONER FRIEDBERG: So if that's correct, if that's the root cause of the problem for many kids, even considerable increases in investment in rural education, it seems like they're not going to help all that much if you get kids who are behind from the very beginning.

DR. ROZELLE: Well, this is what other middle-income countries have found after 60 years of being stuck in this trap, is they've started investing big programs in zero to three. And it's a tough investment, right, for any leader to do.

Because if we start a zero to three program right now to try to improve it their cognitive development and language skills, they don't enter the labor force until 2045, right. And I think that, hence, there is the tension. I think we have this problem in our country too, right. So how much do we invest there versus others.

So these are the perfect questions. So I think that huge investments in rural education are going to have results. And they've had results in the past. But ultimately, there's this huge part of this labor force that has trouble to learn how to learn done.

COMMISSIONER FRIEDBERG: So this a problem then that's existed for some time, probably since the 1990s. To what extent are those problems manifesting Chinese economic performance up until now? This is not something new if I understand correctly.

DR. ROZELLE: Okay. So what you have to understand is, right, I mean, going from poor to middle-income is a very different feat than going from middle-income to high-income. When you go from poor to middle-income, you mobilize inputs, you create markets, you overcome inefficiencies, and you have new technologies and productivity gains.

So these people who are cognitively delayed, they're the ones who would have special education in U.S. schools. And there's no special education system in China. But they can sit in factories and do the repetitive work perfectly fine, maybe even better than kids who are much brighter.

And so the fact that we don't even know that those kids weren't a problem in the past 30 years, but they've become a problem later. And, you know, that's what the experiences of these other middle-income countries have shown.

COMMISSIONER FRIEDBERG: So a big part of the problem looking forward has to do with the change in the nature of the economy and the requirements for productive jobs, right? You could have kids who are underperforming but doing these very repetitive jobs. They may not be very well-suited to the next generation jobs.

DR. ROZELLE: Right. So in high-skill, high-wage, high-income economies, right, a large share of those jobs need math, science, language, computers. And that's the skills that they have trouble doing.

COMMISSIONER FRIEDBERG: Thank you very much.

COMMISSIONER PRICE: Okay. Co-Chair Cleveland?

COMMISSIONER CLEVELAND: Thank you. And thank you all for your really thoughtful remarks.

I'd like to go back to something that Commissioner Helberg raised. And I'm struggling with the idea that, on the one hand, China is able to produce extraordinary technology relatively quickly -- whether they can field it I think we'll hear about later today.

But I guess the question I want to ask is, can the talent pool that China has meet industry and other actors', government, needs? And I want you to address it from the perspective of who's teaching, what are their qualifications? and at the higher ed level, not K-12. Do instructors have relationships with industry in a way that helps ensure that new requirements are met?

And in particular, I'm confused by the data that we'll hear later today that show that there's only 15 to 20 percent of graduates from these new integrated circuit and semi-conductor majors, only 15 to 20 percent are actually securing jobs in industry, even though there's a 200,000-job shortfall.

So I'm puzzled by the disconnect between what students are getting trained in and what industry is complaining about in terms of qualified graduates. Does that make sense?

DR. LOYALKA: I'll try. I think, you know, there's often been a narrative in many, many countries where companies say graduates are no good.

COMMISSIONER CLEVELAND: Yes.

DR. LOYALKA: That's just really ubiquitous, I think. Even in the United States I think you'll find that they'll say that, you know, they lack certain types of skills.

Even in China, where there was always complaints about college graduates not being able to find jobs and having lower returns, we find that actually wasn't true. And people actually did labor market surveys. It's true that people might take a little bit of time to find the right job for them, but there were really high employment rates. And a lot of people would have jobs in which they'd get a very high return that would grow quite rapidly over time.

So I don't know this latest study that you're referring to and what the data is that it's based on.

In terms of the professors in colleges -- and I think Zachary mentioned that there's elite colleges, about 100 of them. In those colleges and the second tier, I would say they have really good access to materials. They do keep up to date with things. They're really savvy on the

Internet. They find the latest U.S. text books, they translate them into Chinese. They use them if they want to learn.

But then I think, whereas the learning isn't, like, great, as my studies have been showing in college, those elite college students, there's a lot of them. There's 100 universities that train a lot of students. By the time they end college, they have skill levels that are equal to the average student in the United States that's graduating from college.

So it's this huge pool of students that's not, like, doing super, super well. But they're doing pretty darn well. They're the equivalent to our own college graduates. And they're entering the labor market, and they're going to be working in industries, is my guess.

COMMISSIONER CLEVELAND: How do you account for the high unemployment rate then?

DR. ROZELLE: Yeah. I mean, I think the real high unemployment rate is a COVID issue in these last, you know, couple of years. And there's a couple papers that have looked at this where, in every single summer in July, and August, and September, the papers are full of "college students can't find a job." And that's what the parents of these urban kids are worried about.

You go to them in the next May, right, the month before the next graduation period, and almost all of them, you know, until recently, have had jobs. And they start at really low levels, right. Migrant workers make more than them. Wait until five years from now, and then they're making three times of what migrants are, twice as what migrant workers are making.

So until recently, until this economic slowdown has really, you know, come to a crawl, and again we don't know if it's policies of the government or if it's COVID, but we see real unemployment now. And that's the issues that are in front, whether the bounce back is going to happen, and they're going to do that. But I think as the economy slows, you're going to see more and more of that. And it's going to become an issue.

COMMISSIONER CLEVELAND: I will have questions for the record on vocational education, but thank you all.

COMMISSIONER PRICE: Thank you, and Commissioner Borochoff.

COMMISSIONER BOROCHOFF: First, thank you, thank you for this hearing. It's provoked so many questions for me that I can't ask any of them except one. I want to start with Dr. Rozelle and tell you that I come from the same era you did.

And early in my career I had a phenomenal, great job, and they were so worried. I worked for a nationwide company, reported to the CEO of the company, and all of us, nationwide, were forced to read specific books about Japanese management. I was forced to go through classes about Japanese management, and I'm very thankful they did that. Because that is what encouraged me to quit and go start my own job, and start my own business. And I've been self-employed ever since.

Secondly, I spent ten years of my life in an unpaid community contribution role where I live working on early childhood development, because of a member of my family, and learning a lot about what you've been discussing today. I wish we had time to talk more about that, but have a different question.

Mine's a fairly simple question. I'm not sure of the answer. I have an acquaintance who was the CEO of a private university firm that operates in China and still does today, very proud of what they do, she is. She's not doing that now.

I know they only had a few, maybe a dozen schools. I don't know if they're the only one. I'm very interested in all of your perception about private universities in China, and how are they perceived there.

Obviously they must be -- they wouldn't be there if the government didn't see some kind of value. Are they state supported? Are they any good? Or are these, as Vice Chairman Wong mentioned, are they perhaps part of the corruption that occurs to get into schools? I just want you impressions of how do they operate, and what are they all about?

DR. LOYALKA: Yeah, so the first two tiers of colleges in China are four-year public colleges. The next tier is four-year private colleges. And there's a reason they're the third tier. When you take the college entrance exam to get in, if you score lower, you get into one of those colleges. The tuition is twice as much. Their quality is really bad.

I mean, so if first and second-tier students aren't learning in college, I can guarantee the third-tier university students are probably not learning.

Below that is what they call three-year vocational type of colleges. Those are both public and private, about half and half. And also there haven't been any systematic studies that at least I know of. I don't think we know of any. But I imagine the quality there isn't very good either for the same reason.

COMMISSIONER BOROCHOFF: So effectively you're saying that they aren't having any real impact. And the reason they're being allowed to operate is for probably that reason.

DR. LOYALKA: Yeah, I don't think they're really having very much impact. I think it helps take in more college enrollment which is helpful to the state, you know, giving people that sense that they're going to college and provides more legitimacy to the state. And the state isn't, you know, paying very much for it at all.

DR. ROZELLE: Yeah. And in the three-year vocational colleges, there are -- I mean, these are kids that went through the academic high school level, and then they get into these vocational colleges. And they do get exposed - To them it's sort of like practical training. Half of the time they spend as interns. And so they're paying tuition, and then they go to work for free for companies. But they're getting experience in some cases. So it's a tough thing, like we said. Nobody's even studied it.

COMMISSIONER BOROCHOFF: It's an expensive form of upskilling.

DR. HOWLETT: I'd just add that vocational colleges and programs, people who attend those are widely seen as failures. Which is a big impediment to reform.

In relation to the earlier points, anecdotally students from China are telling me that even those graduates from top 40 public universities need a masters to get a job now in the current environment.

COMMISSIONER BOROCHOFF: Thank you all very much.

COMMISSIONER PRICE: Okay, Commission Chair Bartholomew.

CHAIRMAN BARTHOLOMEW: Thank you very much. And thank you to our witnesses both for your testimony today but really also for the work that you've been doing throughout your careers. These are really important issues.

So I have a number of questions. If there's a second round, I'll probably need it, or I'll put them in the record. I guess first, one of the things that we know about lifting incomes, particularly in rural and poor areas, one of the major differentiating factors is the education of the mother, education of girls, education of the mother.

And I'm wondering if you could talk a little bit since a lot of times girls have been devalued in rural Chinese culture. And girls are often the first people who are pulled out of

school in order to help around the house. What about the participation rates of girls in rural areas?

DR. ROZELLE: This is another area that we've looked a lot at. And I think you're going to be surprised and not surprised by the answer.

First of all, in rural China the status of girls has risen dramatically in the past 10, 15 years going along. But where you see it the most is they can get a job off the farm. So now they can contribute directly to income. And number two, there's a huge sex imbalance, gender imbalance in the marrying age right now.

And then I guess third is on Chinese TV there is constant sort of propaganda, and good propaganda, that talks about how girls, you know, will take better care of their parents than boys which is probably true. And so this is the --

So we do these studies on zero to three babies, with 2,000 parents with kids. And about one-quarter of them will have two girls. And we'll ask the parents, the mom, are they going to have another child, because they need a boy. And almost systematically they say no, two is enough. And they say does your mother-in-law want a boy? Yes, right, but they don't, and they just basically say --

The other thing I want to say is we then have looked at the cognition levels of baby boys and girls at three. Performance in pre-school, K-12, and college, and in all of those levels girls do better than boys. And the admissions of girls to colleges is now higher than that of boys. That's the surprising news.

The unsurprising news is as soon as they enter the labor market, which is typically an urban labor market, they are very much discriminated against. And their salaries are lower, promotion is lower, and it has to do with they're going have babies soon, and have to take care of them, and not focus on their jobs and be worried more about their family.

So it's a good questions, and I think it's surprising, but I think that you can understand it in the evolving of the Chinese economy.

CHAIRMAN BARTHOLOMEW: So women are not holding up half the sky.

DR. ROZELLE: Say that again.

(Simultaneous speaking.)

CHAIRMAN BARTHOLOMEW: I said so women are not holding up half the sky, not when it comes to the labor force.

DR. ROZELLE: In the labor force, they're not holding up half the sky. In the education system, they're holding up 60 percent of the sky.

CHAIRMAN BARTHOLOMEW: Do either of our other witnesses have anything to add? If not, Dr. Rozelle, I have a specific question for you.

DR. HOWLETT: I would just add really quickly that there sort of is a perception that women's out performance in China is due to the one child policy. But in fact, in many rural areas, there are three or four children in many families, and daughters are competing with sons and son preference to do so well in education. And now they number 54 percent in college. And they've overtaken men in graduate school as well, despite a distorted sex ratio at birth.

And this is also a global phenomenon, it's not just in China. Women are outdoing men in education globally.

CHAIRMAN BARTHOLOMEW: They just need to be given a chance to do the labor force properly.

Dr. Rozelle, another question for you. This is putting you on the spot a little bit. I understand that you testified before this Commission in 2004 on challenges for China's future economic development. I'm wondering if you could tell us what you've learned about this, watching this for the past 20 years, and if any of your expectations from 20 years ago have played out differently?

DR. ROZELLE: Yes. So I often say -- We went to a conference in about 2006, so the recent -- very soon after I testified here, and we were talking about the future growth of China. And all of the economists in that group were talking about how China was on its way. And they were going to continue to develop, et cetera. I'll keep this short.

And the political scientists in the group said be careful. There's things underway that are going to -- and I think since that time, the shift from market to planning, the continued over-investment in sort of infrastructure and government investment versus trying to foster consumption, the economists that work on China have turned from these optimists to pessimists.

So we were wrong 20 years ago. And, you know, I think that that's where we find ourselves today. So it's, you know, very good questions.

I used to work fully on agriculture. Now I work fully on human capital. I think that that's a shift in the economy.

CHAIRMAN BARTHOLOMEW: And have any of the three of you seen any changes in either the orientation of the education system or the emphasis on the education system since Xi Jinping took over? Don't hear any response?

DR. ROZELLE: So did we see changes in the, what part of the education --

CHAIRMAN BARTHOLOMEW: I'm just wondering if the education system as you have seen it and watched it over your career has changed in any way since Xi Jinping took power. Is it on the same trajectory, what's being taught, how it's being taught, emphasis on education? Or have there been any changes to that?

DR. HOWLETT: I mean, I think, coming back to Commissioner Goodwin's question, there is always going to be sort of perennial calls from more emphasis on creativity and on innovativeness. Xi Jinping has also reinforced ideological education.

But at the end of the day, people in China say that what they call a multi-factor admission system like we have in the United States just won't work in China, because it could be corrupted. Because the recommendation letters could be paid for, and athletic accomplishments could be faked. And we saw with the admission scandals in the States that that indeed happens.

So I think that there is just both continuity and change. Xi Jinping has really, as part of the general tenor of the anti-corruption drive, there's been sort of a suppression of back doors, and of bonus points, and that kind of thing, and on the other hand, at trying to push creativity and innovation. But it's a very difficult juggling game to maintain.

CHAIRMAN BARTHOLOMEW: Thank you. I think my time is up.

COMMISSIONER PRICE: Thank you. And thank you to all of you for your excellent testimony and answers to our questions. We're going to take a short break, and we will be back in about six or seven minutes. Thanks.

(Whereupon, the above-entitled matter went off the record at 10:57 a.m. and resumed at 11:06 a.m.)

PANEL II INTRODUCTION BY COMMISSIONER ROBIN CLEVELAND

COMMISSIONER CLEVELAND: Welcome. Our second panel will examine the role of China's higher education system in supporting China's innovation ecosystem. We'll start with Dr. Xin Xu, who's appearing remotely, a Research Fellow at the Center for Global Higher Education in Oxford University's Department of Education. She will discuss the party-state control, influence over the higher education system.

Next, we'll hear from Ms. Anna Puglisi, who's Director of Biotechnology Programs and a Senior Fellow at the Center for Security and Emerging Technology, who will provide us with an analysis of China's system: research institutes and universities and how they develop science and technology. And then, we'll hear from Dr. Jeffrey Ding. Welcome back.

Assistant Professor of Political Science at George Washington University, Dr. Ding will assess the ability of China's --- I'm reading what the staff wrote, and I don't understand it, so I'm going to change. Dr. Ding will assess diffusion of technological advances and the role that is supported by China's education system. Thank you very much for your testimony. I know it's complex. I've read it with great care but try to keep it to seven minutes because, as you know, we ask a lot of questions. So Dr. Xu, we'll begin with you for your brief overview. Thank you.

OPENING STATEMENT OF XIN XU, RESEARCH FELLOW AT THE CENTRE FOR GLOBAL HIGHER EDUCATION, UNIVERSITY OF OXFORD

DR. XU: Thank you very much for the kind introductions and thank you so much again for this opportunity to contribute to this hearing. Since I'm currently based in the U.K., I also thank you for the opportunity to join online.

I'll draw on my written testimony and present three major themes about Chinese's higher education and research, particularly humanities and social sciences research. Although they may seem paradoxical, they need to be understood, not from so-called Western frameworks but from the lens of Chinese history, reality, cultures, including political cultures.

The first paradox is about the governance of Chinese higher education, which is a combination of centralization and decentralization. So throughout the years, institutions and individuals in China have had an increasing degree of autonomy in many aspects in higher education. However, the central government still has power over important aspects of China's higher education and research. This is reflected, for instance, in the importance of the national Double First Class University programs and the previous 985 and 211 university programs.

The second paradox is about China's research, particularly Chinese humanities and social sciences research, which demonstrates affiliations and tensions between internationalization and indigenization, or the so-called Chinalization or Chinafication. We need to delve back into history to understand this paradox. For thousands of years, humanities have been vital in Ancient Chinese scholarships.

But since the Western invasion in the 19th century, Chinese people started to turn to Anglo-European sciences and established social sciences disciplines following Western frameworks. So nowadays, while China is the largest producer of the science and engineering publications in the world, its humanities and social sciences research is not as visible. And this is partly because global humanities and social sciences research is still Anglo-European dominated, so we know that more than 90 percent of research indexed by global databases are published in English language, but the main language for publication in Chinese humanities and social sciences is still Chinese. So this means that many of the knowledge produced in China is not visible in the world.

For many years, China's government has been encouraging the, going out, of Chinese humanities and social sciences research to make Chinese voices heard in the world. But on the other hand, Chinese humanities and social sciences research will never be completely internationalized. This is because, unlike sciences, humanities and social sciences are much more rooted in local and national cultures and realities.

And in China, there have been long-standing debates about, and concerns about, self-colonization of Chinese research and pushbacks towards Westernization, and policies have also been emphasizing our valuing Chinese cultures, traditions, theories, and making impacts on Chinese society.

The third paradox is about academic freedom and autonomy. The Chinese academics face conflicts between the need to pursue knowledge freely, between institutional and national controls, as well as between their own desires to contribute to nation-building. Again, back into the history, for thousands of years, in Ancient China, Confucian intellectuals see themselves as having responsibilities to contribute to the society, ensure social order and stability of the nation, and be dedicated to benevolent governance.

But on the other hand, Confucian learning also highlights the importance of academic freedom. Not every academic in China now still embraces the traditional Confucian values, but the tradition is still influential, so in China, academic freedom is paradoxical. It can be seen more often in some cases than in others.

In addition, Chinese researchers also face influences that are outside China, such as the COVID-19 pandemic --- I mean, it's also in China --- but also the U.S.-China geopolitical tensions. For instance, our studies have found that racial profiling among Chinese ethnic scientists in the United States in recent years have been negatively impacting China-U.S. research collaborations.

And to conclude, I would like to propose two recommendations. Firstly, it would be helpful to learn more about Chinese higher education and research. In general, I would argue that China knows more about the United States' higher education and research than the U.S. knows about China. And this is not only because of the past influence of the U.S. on Chinese higher education and research but also that China has more interest to learn about and learn from the United States than perhaps the other way around.

Although there are large differences between both countries, there are also common grounds and similarities. Therefore, this really highlights the importance of the Commission's work here, and also, it suggests potential needs for the U.S. government for more people who have Chinese language capacity, a good understanding of Chinese cultures -- including the political cultures -- a willingness to learn about a complex and ever-changing system, and a willingness to apply not only the U.S. framework to understand China, but understand China through China's lenses.

And secondly, despite lots of challenges in humanities and social sciences research and regardless of how the U.S.-China relationship unfolds in the future, the two countries are undeniably science giants in the world with close collaboration ties. It will be a loss of opportunities for both China and the United States if both parties stop collaborating with each other, particularly in humanities and social sciences research.

As noted, although academics can be influenced by national structures, institutional structures, they're not bounded within national borders. They can also work and collaborate internationally. So therefore, it is possible to build mutually beneficial collaborations among researchers in both countries, hopefully on the basis of mutual respect and equality. So with this, I conclude my testimony, and thank you very much for listening. I look forward to further discussions later.

PREPARED STATEMENT OF XIN XU, RESEARCH FELLOW AT THE CENTRE FOR GLOBAL HIGHER EDUCATION, UNIVERSITY OF OXFORD

Chinese Higher Education and (Humanities and Social Sciences) Research

Testimony prepared for
U.S. – China Economic and Security Review Commission

Hearing on 'China's Challenges and Capabilities in Educating and Training the Next Generation Workforce'

Dr Xin Xu

Research Fellow at the Centre for Global Higher Education,
Department of Education, University of Oxford

14 February 2023

Thank you for this opportunity to contribute to conversations about Chinese higher education and research. This testimony addresses questions raised by the U.S.-China Economic and Security Review Commission. Key points include:

1. The governance of Chinese higher education and research is a combination of centralization and decentralization. While institutions and individuals have an increasing degree of autonomy in many dimensions, the central government has power over important aspects of higher education and research.

2. Humanities and social sciences research's role in China has undergone significant changes throughout Chinese history. The past few decades have witnessed the increasing policy attention to humanities and social sciences research.

3. Chinese humanities and social sciences research oscillates between internationalization and indigenization.

4. Academic freedom for individual researchers in China faces tensions between individual pursuit of intellectual freedom, individuals' commitment to the public good, control and influences from institutions and policy, and international influences.

1. The governance of Chinese higher education and research

The governance of contemporary Chinese higher education combines decentralization and centralization. While institutions and individuals have an increasing degree of autonomy in many dimensions, the central government has tightly held the real power.

1.1 Decentralization of governance

Since China's Reform and Opening Up in 1978, the Chinese government has been decentralizing its governance of higher education and research institutions. Decentralization happened in many areas. For instance, the first *Higher Education Law* published in 1998 devolved the management of universities from the central government to local governments, universities and non-state sectors. It regulated that local universities shall be under the governance of provincial governments, rather than national ones; and universities were designated as independent legal entities, which shall have autonomy in teaching, research, administration, etc.[1]

Another example is the national college entrance examination (*Gao Kao*), the largest exam in the world that involved 11.9 million examinees in 2022.[2] Every high school graduate in China must pass the examination to enrol in higher or tertiary education institutions. When *Gao Kao* started in the 1950s, its contents, procedures and student recruitment were under the control of the Chinese central government. But over the past few decades, local governments and Chinese universities have gained increasing autonomy in deciding the contents and procedure of the examination. Many universities were also granted rights to conduct 'independent admission' prior to or in addition to *Gao Kao*, to admit students based on their own tests[3].

In terms of funding, the central government has also been diversifying the funding bases for higher education institutions. This was initially done with the introduction of tuition fees. Along with the marketization in Chinese society, more and more private higher education institutions also emerged. Similar trends happened in research funding too. For Chinese researchers, there are mainly two types of research grants, namely 'vertical grants' (*zong xiang ke ti*) and 'horizontal grants' (*heng xiang ke xi*). The difference lies in the funding sources and research aims. 'Vertical grants' receive allocated or commissioned funding from the government and public sectors. 'Horizontal grants' receive funding from both the public and private sectors, and are mainly for knowledge transfer, technology services, and industry cooperation. The number and scale of 'horizontal grants' have been increasing over time. [4]

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[1] Higher Education Law of the People's Republic of China (in Chinese). (1998). http://www.npc.gov.cn/wxzl/wxzl/2000-12/05/content_4712.htm.
[2] Record 11.9m students to take gaokao with full preparations under shadow of COVID-19. https://www.globaltimes.cn/page/202206/1267415.shtml
[3] Han, S., Xu, X. (2019). How far has the state 'stepped back': an exploratory study of the changing governance of higher education in China (1978–2018). *Higher Education* 78, 931–946. https://doi.org/10.1007/s10734-019-00378-4
[4] Gao, Z. (2013). A comparison between vertical and horizontal research projects [In Chinese]. *Economic Research Guide*, *197*(15), 264–265.

1.2 Central government's control over higher education and research

Nonetheless, the central government still has fundamental power and control over higher education and research in China. One important mechanism to exert such influences is through publishing national policies, which set goals and plans for the development of Chinese higher education and research. Those policy documents' titles often started as *Suggestions*, *Opinions*, *Decisions* etc., but they have a law-abiding effect[5]. Although as noted, institutions and individual academics have much autonomy in many aspects, they tend to treat national policies as 'conductor's batons' to guide their practices. [6]

Changing policies on Chinese humanities and social sciences research

Regarding the development of Chinese humanities and social sciences (HSS) research, the government has issued many policies since the late 1970s, to encourage both the internationalization and indigenization of HSS research.

(a) The internationalization of humanities and social sciences research

The encouragement of internationalization was manifested by so-called 'going out' (*zou chu qu*) policies since the 2000s, which built on the economic strategy of 'going out' for overseas investment.[7] The context was that while Chinese HSS research has been developing, it has not been internationalized to the same extent as the fast-growing STEMM (Science, Technology, Engineering, Math and Medicine) research. According to the U.S. National Science Foundation Report (2022), China now ranks first globally in terms of the total number of international publications (primarily publications in the English language) in science and engineering, and second in terms of highly-cited publications.[8] But HSS research in China shows a different picture. The world share of international publications from China was around 5% in 2018, a low ratio when compared to the U.S. (around 25-30%) and the U.K. (around 10%).[9] The social sciences publications from China only accounted for 1.04 per cent of its international publications, in contrast to the high-performing science disciplines such as engineering (25.47 per cent of its international publications).[10]

To improve the visibility of Chinese HSS research in the world, enhance its internationalization level, and thus promoting the 'discourse power' of China, the government then issued a series of

[5] Law, W. (2002). Legislation, education reform and social transformation: the People's Republic of China's experience. *International Journal of Educational Development, 22*, 579–602.
[6] Xu, X. (2020). Performing under 'the baton of administrative power'? Chinese academics' responses to incentives for international publications. *Research Evaluation*, *29*(1), 87-99.
[7] Office of the State Council. (2006). *To further implement "Going-out" strategy [In Chinese]*. Retrieved from http://www.gov.cn/node_11140/2006-03/15/content_227686.htm.
[8] US National Science Foundation. (2022). *The state of U.S. science and engineering 2022.* https://ncses.nsf.gov/indicators
[9] Zhang, L., Shang, Y., Huang, Y., & Sivertsen, G. (2020). Toward internationalization: A bibliometric analysis of the social sciences in Mainland China from 1979 to 2018. *Quantitative Science Studies*, 1–33. https://doi.org/10.1162/qss_a_00102
[10] US National Science Foundation. (2020). *The state of U.S. science and engineering 2020*. https://ncses.nsf.gov/indicators

policies to encourage the 'going out' of Chinese HSS research in the 2000s. In response to the 'going out' strategy, many Chinese universities had been encouraging and incentivizing HSS academics to publish internationally, collaborate internationally and be more proactive to engage with international research. The incentives mainly came in two forms: monetary bonuses and career-related incentives, both largely based on the number (quantity) of publications rather than the quality. Such incentives first appeared to encourage the internationalization of STEMM research, but a growing number of universities started to apply incentive schemes to HSS research under the influence of national policies. Universities had different incentive schemes. In general, STEMM international publications were rewarded or valued more than HSS international publications, and international publications were valued more than domestic publications. A publication in *Nature* or *Science* could lead to a bonus of one million RMB (around 146,000 USD) at some universities; while the highest bonus for a HSS international publication was 200,000 RMB (around 29,000 USD) at some universities.[11]

(b) The indigenization of humanities and social sciences research

The other side of the coin is that the government has also been emphasizing the indigenization of Chinese HSS research. To understand the rationales, we need to first revisit the characteristics of HSS research: while in STEMM research, the use of English language is more common and research is less dependent on contexts, HSS research is rooted in local/national cultures, ideologies, languages and traditions. However, the infrastructure, norms and language in global HSS research is largely 'Western' (Anglo-European) dominated. For instance, in the widely used databases in the world – *Web of Science* and *Scopus* – more than 92 per cent of the indexed publications were published in English.[12] This means that for HSS researchers in non-Western countries, they are not in a level-playing field when engaging with 'global' HSS academia. For Chinese HSS academics for example, they could face multi-layered discrimination and bias when participating global knowledge production. The bias could be based on their ethnicity, nationality, use of language, research paradigm and questions, assumed ideological positioning, assumed cultural attachments, etc.

In China, the situation is further complicated by historical contexts. Historically, the role of HSS has experienced several major changes. For thousands of years, humanities had been vital in Ancient Chinese scholarships. Students and academicians at that time need to be knowledgeable in Chinese classics (with Confucianism as one major school of thoughts) to pass the *Ke Ju* (the

[11] Xu, X., Rose, H., & Oancea, A. (2019). Incentivising international publications: Institutional policymaking in Chinese higher education. *Studies in Higher Education*, 1–14. https://doi.org/10.1080/03075079.2019.1672646
[12] Vera-Baceta, MA., Thelwall, M. & Kousha, K. (2019). Web of Science and Scopus language coverage. *Scientometrics* 121, 1803–1813. https://doi.org/10.1007/s11192-019-03264-z

Imperial Examination to select civil servants), and then to become state officials – a much-aspired occupation then. [13]

But the first major change occurred with the Western invasion in the 19th century, when Chinese people started to shift their attention from traditional Chinese scholarships to Western 'sciences' – as the latter were perceived as symbols of modernization and advancement. Since then, the development of Chinese HSS research has borne Western imprints. Many of the social sciences disciplines were established and institutionalized following Western theories, norms and methods. Traditional Chinese scholarships, in comparison, received gradually less attention. . HSS research were also valued less than sciences. [14]

Since the establishment of P.R.China in 1949, HSS research first experienced a high degree of politicization and censorship during Mao's era (including during the Cultural Revolution), and became detached from the world. Then since the Reform and Opening-up in 1978, the rehabilitation of HSS started. While Deng Xiaoping and the Chinese government then emphasized that HSS research was important, the policies started with focusing on the development of STEMM subjects as drivers for economic growth. While HSS research was developing, it did not receive the same level of attention or support as science subjects. The internationalization of Chinese HSS at that time was also one-way borrowing and learning from the West. [15]

It was not until the 2000s, that the government started re-emphasizing the importance of HSS research to Chinese society, the importance of Chinese traditions and cultures, and the importance of upholding Chinese ideologies. In Xi's China, traditional Chinese values and philosophies have been more repetitively emphasized in policies, some of which underpinned important policy discourses. For instance, the discourse on 'the community with a shared future for humankind' has taken roots in the traditional Chinese philosophical belief that 'all under heaven are of one family'.[16]

Since the Reform and Opening-Up, there have been long-standing debates in policy and academic discourses, about whether HSS research should be internationalized, to what extent it should be internationalized, and what are the risks to its indigenization (e.g. some academics were concerned about the 'self-colonization' of Chinese HSS research through internationalization[17]). Throughout the years, the central government has emphasized repetitively

[13] Xu, X. (2021). A policy trajectory analysis of the internationalisation of Chinese humanities and social sciences research (1978–2020). *International Journal of Educational Development*, 84. https://doi.org/10.1016/j.ijedudev.2021.102425
Yang, R., Xie, M. & Wen, W. (2019). Pilgrimage to the West: modern transformations of Chinese intellectual formation in social sciences. *Higher Education,* 77, 815–829. https://doi.org/10.1007/s10734-018-0303-9
[14] ibid
[15] ibid
[16] ibid
[17] Dang, S. (2005). Can American standards set the highest evaluation benchmark for Chinese Social Sciences? – Take SSCI as an example [In Chinese]. *Social Sciences Forum*, *4*, 62–72.

in policies that Chinese HSS research should not be completely 'Westernized'; rather, it emphasized that Chinese HSS research should be rooted in Chinese cultures and traditions, guided by Marxism ideologies with Chinese characteristics, and bring impacts on contemporary China.[18]

In addition to issuing policies, China has developed its own scientific indices – such as CSSCI (Chinese Social Sciences Citation Index) – that indexes a bulk of selected Chinese scholarly journals. China has established an independent HSS research institution, the Chinese Academy of Social Sciences (CASS), and has established many reputable domestic scholarly journals. The dominant language of publication in China's humanities and social sciences research remains Chinese. There are large bodies of research published in Chinese each year that were not visible to the world, since they were not translated into other languages or indexed by the Web of Science/Scopus.[19] The quality of Chinese publications in HSS varies journal by journal, publication by publication; but in terms of academic rigour and quality, there exists research of high quality. Unlike in science and engineering, where high-quality research has mostly been published in English, many of the high-quality scholarships in HSS are still being published in Chinese. China has also developed its own world university ranking – the Academic Ranking of World Universities (ARWU, also known as Shanghai Jiaotong University Ranking, or Shanghai Ranking), which is considered by many as the forerunner of world university rankings. All demonstrate persisting efforts to develop Chinese research in Chinese terms and to Chinese standards.

In 2020, the government issued a series of policies to reform research evaluation in China, to stop valuing only papers, hats (meaning academics who are part of talent programmes), titles, diplomas, and prizes in research evaluation – termed as 'breaking down five-onlys' (*po wu wei*). The policies firmly abolished incentives and monetary bonuses for international publications, to stop the 'worship of SCI publications' (meaning over-valuing publications in international journals indexed by the Science and Citation Index (SCI)), to encourage the development of Chinese journals and indices, and to value quality over quantity in research evaluation. The policy also explicitly maintained that HSS research should not 'deliberately dwarf or vilify China' or 'damage national sovereignty security and national interests' for the sake of publishing internationally.[20] These policies also argued that Chinese researchers should 'write papers on the homeland' (quoting words from a speech by President Xi Jinping in 2016)[21]. All of these policies indicated stronger signals and pushes for the indigenization of Chinese (HSS) research.

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[18] Xu, X. (2021). A policy trajectory analysis of the internationalisation of Chinese humanities and social sciences research (1978–2020). International Journal of Educational Development, 84. https://doi.org/10.1016/j.ijedudev.2021.102425

[19] Zhang, L., Shang, Y., Huang, Y., & Sivertsen, G. (2020). Toward internationalization: A bibliometric analysis of the social sciences in Mainland China from 1979 to 2018. *Quantitative Science Studies*, 1–33. https://doi.org/10.1162/qss_a_00102

[20] Ministry of Education. (2020). Opinions on eliminating the unhealthy 'paper-only' orientation in the evaluation of humanities and social sciences research in higher education institutions [In Chinese] http://www.moe.gov.cn/srcsite/A13/moe_2557/s3103/202012/t20201215_505588.html

[21] ScienceNet. (2016). *Xi Jinping: Write papers on the homeland [In Chinese]*. https://news.sciencenet.cn/htmlnews/2016/6/348350.shtm

Consequently, institutions have to stop providing monetary bonuses for international publications, and individual researchers now have more choices of whether to engage more internationally or domestically. Some researchers suggested that the recent policy shift may slow down China's research internationalization or decouple it from international collaborations. But my understanding is that the internationalization process will not stop. China's research has been facing tensions between internationalization and indigenization throughout the years. Consequently, the oscillations between being open to the world and being more nationally/locally oriented have been in play for many years. The current shift was more of an attempt to strike a balance between international and Chinese research, so that Chinese research and higher education do not become over-Westernized, or over-emphasize quantity rather than research quality.

In addition, research activities operate not only at the national scale but also at the global scale. While research is often dependent on funding, affiliation and infrastructure within nations, researchers are not bounded by single countries. Research networks can exist beyond nations, and are dependent on the agency of researchers.[22] Therefore, researchers and institutions in China with existing ties and interests in international collaborations may continue their engagements globally despite the policies. However, those who did not had the interest or need for international publications or collaborations can now choose more freely where to publish etc. This may reduce tokenistic behaviours in research, making institutions and academics pay more attention to research quality and integrity.[23] Nonetheless, because of the lag between research being conducted and published, we will need to follow up with the evidence in the next few years, to see how these policies influence the international engagements of Chinese (HSS) researchers.

National funding for higher education and research

Another important example of the government's influence is that national funding for higher education and research still plays a central role in the sector. The most prestigious universities in China are largely public (and research-intensive) universities funded by the government. The most important national higher education programme in China is now the Double First Class University Programme, which aims to build both first-class universities and first-class disciplines. It was launched in the late 2010s to replace the previous 985 and 211 programmes, which were initiated in the 1990s with similar goals to build world-class universities. [24] Universities and respective disciplines selected to join the Double First Class University

[22] Marginson, S. (2022). What drives global science? The four competing narratives. *Studies in Higher Education*, *47*(8), 1566-1584.
[23] Xu X. (Forthcoming). Research evaluation in China: Policy, practice and prospects. In Oancea A., Derrick G., Xu X., Nuseibeh N. (eds.), *Handbook of Meta-Research*. Edward Elgar Publishing.
[24] Ministry of Education, Ministry of Finance, & National Development and Reform Commission. (2017). Releasing the lists of "world first-class universities" and "world first-class disciplines" [In Chinese]. http://www.moe.gov.cn/srcsite/A22/moe_843/201709/t20170921_314942.html

Programme would enjoy higher prestige, abundant funding from both national and local governments, and more resources and support in many aspects. [25]

One important change from the 985/211 programmes to the Double First Class University Programme was a shift from ex-ante assessment to performance-based funding. This means that now universities selected to join the Programme would be evaluated every few years. Only those who keep performing well will remain in the Programme.[26] The assessments focus on six dimensions: students' cultivation, teaching, research, social service, the inheritance and innovation of Chinese culture, and international exchange and collaborations.[27] In this way, the central government keeps playing important roles in assessing and assuring the quality of higher education and research in China.

The government's influence also showcases in research funding. Despite the growth of 'horizontal grants' over the years, 'vertical grants' funded or commissioned by the government are still regarded as the most rigorous, competitive and prestigious. Some of the funding schemes would signal directions of research the government encourages. For example, there has been a growth of nationally funded research grants in Marxism and the history of the Chinese Communist Party over the past decade. [28]

2. The role of Chinese (humanities and social sciences) academics

Chinese academics have a unique relationship with institutions and governments. To unpack the complexity, we need to again delve back into Chinese history. For thousands of years in Ancient China, Confucian intellectuals had perceived themselves as having responsibilities to contribute to society, ensure social order and the stability of the nation, and be dedicated to benevolent governance.[29] As Neo-Confucian Tu Weiming suggested:

> Confucian followers were primarily action intellectuals, deeply immersed in "managing the world" (*jingshi*) of economics, politics, and society. Their strategy was to transform the world … through culture, specifically through moral education. … Confucian

[25] Han, S., Xu, X. (2019). How far has the state 'stepped back': an exploratory study of the changing governance of higher education in China (1978–2018). *Higher Education* 78, 931–946. https://doi.org/10.1007/s10734-019-00378-4
[26] Ministry of Education, Ministry of Finance, & National Development and Reform Commission. (2017). Releasing the lists of "world first-class universities" and "world first-class disciplines" [In Chinese]. http://www.moe.gov.cn/srcsite/A22/moe_843/201709/t20170921_314942.html
[27] Ministry of Education, Ministry of Finance, & National Development and Reform Commission. (2020). *Notice on publishing the "Methods to evaluate the effectiveness of the 'Double First Class Programme' (pilot)" [In Chinese]*. http://www.moe.gov.cn/srcsite/A22/moe_843/202103/t20210323_521951.html
[28] Huang, H., Zhou, Y. (2021). Research on Changing Trend of Distribution of Social Science Research Forces: Based on Statistical Analysis of National Social Science Fund in the 13th Five Year Plan [In Chinese]. Science and Technology Management Research, 19: 204-210.
[29] Zha, Q., & Shen, W. (2018). The paradox of academic freedom in the Chinese context. *History of Education Quarterly*, 58(3), 447-452.

> scholar-officials were perceived of as the conscience of the people, for they served the long-term well-being of the entire country.[30]

Not every academic in contemporary China still embraces traditional Confucian values. But the tradition is influential. Arguably, a higher proportion of Chinese academics – particularly those in humanities and social sciences – could be more interested in contributing to institutional and national policy making than their colleagues in many other countries. As Zha and Shen discussed in their article:

> Academic freedom that is a "totem" for the vast majority of American scholars may not necessarily be highly expected for some Chinese scholars, and they may sacrifice their faith in academic freedom to serve the interests of the people and the government. … Chinese universities and scholars are enthusiastic about instituting public policy think tanks on campus and having government officials and leaders recognize their work.'[31]

Indeed, in many Chinese universities, if academics' suggestions and reports submitted to governments (national, provincial, local) received substantive feedback or approval, these would be counted as research outputs and/or be rewarded.[32]

The compliance with the national agenda can be partly attributed to a willingness to contribute to the public, but it could also be the results of the governance structure and mechanism of higher education and research. For example: as discussed earlier, the importance of the Double First Class University Programme and the importance of nationally funded research projects mean that institutions and individual academics need to follow criteria set by the national government in their operation, research and teaching. As noted earlier, this is reflected in topics in nationally funded research. Research also found that among Chinese publications, there has been a tendency for academics to 'chase the (research) hotspots' influenced by national policy orientations and discourses.[33]

Nonetheless, the Confucian knowledge tradition is not all about obedience. Paradoxically, Confucian learning highlights the importance of free thinking and free handling of academic affairs. Some important traditional Chinese academies, such as *shu yuan*, were also privately funded and operated to ensure freedom of thinking. Some leading universities in contemporary

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[30] Tu, W. (2005). "Intellectuals in a World Made of Knowledge," *Canadian Journal of Sociology* 30, no. 2 (Spring), 200. Cited from: Zha, Q., & Shen, W. (2018). The paradox of academic freedom in the Chinese context. *History of Education Quarterly*, 58(3), 447-452.
[31] Zha, Q., & Shen, W. (2018). The paradox of academic freedom in the Chinese context. *History of Education Quarterly*, 58(3), 447-452.
[32] For instance: Rewards for think tank outputs at Beijing Forestry University [In Chinese]. https://kyc.bjfu.edu.cn/gsgg/xxxg/382872.html
[33] Xu, J. (2006). New development of research on Chinese higher education internationalisation [In Chinese]. *Heilongjiang Researches on Higher Education*, *152*(12), 4–9.

China, like Peking University and Fudan University, also exemplified the ethos of academic freedom and autonomy during various historical periods.

Conflicts between the need to pursue knowledge freely and the desire to be dedicated to nation-building can lead to a paradoxical situation for Chinese academics. In my interviews with 75 HSS academics, administrators and editors in China from different institutions, they expressed various attitudes and responses to national and institutional policies. Some of the responses were supportive, while some were resistant. HSS academics reported having more academic freedom in certain areas, such as in deciding teaching content. But some reported having less space for academic freedom, if their research topics could be deemed politically sensitive. Before the abolishment of incentives for international publications, some academics also felt pressured to publish internationally, since their research scope and interest spoke more to local contexts rather than international ones, or the language of their research should be in Chinese rather than in English. [34]

Academic freedom in terms of international engagement, mobility, communication and engagement is another issue worth noting. The limitations on academic freedom apply not only to Chinese academics, but also international academics working in China. For instance, previous interviews with international academics in China revealed that participants in HSS disciplines more often reported limitations in academic freedom than academics in other disciplines. International academics also reported issues about Internet censorship, which is another challenge academics and students generally face in China. But the access to Internet vary across institutions – institutions with higher prestige and more active international activities tend to have institutional VPNs to pass the firewalls.[35]

In the past few years, Chinese academics and institutions' engagements with the world have also been influenced by many other factors: the COVID-19 pandemic and consequent issues (e.g. lockdowns, online teaching and working); the geopolitical tensions between China and the U.S., which started before the pandemic and became even intensified during the pandemic; the political trends towards more nationalist framing in many parts of the world; and the anti-racism and decolonial movements in many parts of the world. For example, research found that the racial profiling among Chinese scientists in the U.S. among the geopolitical tensions had been negatively impacting China-U.S. research collaborations.[36] As discussed earlier, researchers can be influenced by both national structures, and international communities and networks. Therefore, it is worth noting these influences beyond national borders. Unfortunately though, we

[34] Xu, X. (2020). Performing under 'the baton of administrative power'? Chinese academics' responses to incentives for international publications. *Research Evaluation*, *29*(1), 87-99.
[35] Xu, X., Braun Střelcová, A., Marini, G., Huang, F., & Cai, Y. (2022). International academics in mainland China: what do we know and what do we need to know?. *European Journal of Higher Education*, *12* (sup1), 416-433.
[36] Li, X. & Lee, J.J. (2022). US–China Geopolitical Tensions: Implications for Universities and Science. International Higher Education, 10: 21-22.

will need to wait for solid evidence about the impacts of these events on China's research in the next few years.

3. Policy recommendations

Based on these discussions, I would like to propose two recommendations:

1. It could be helpful to deepen understanding of Chinese higher education and research. China is much more knowledgeable about U.S. higher education and research, than the U.S. is about China. China's knowledge about the U.S. came from both the historical influence the U.S. has had on its higher education (as noted earlier), but also the interest to learn from and about the U.S. Nonetheless, there are several challenges for the U.S. to understand China better:

- Language is the first challenge. Most Chinese students and academics (particularly in research-intensive universities) are now bilingual, meaning they can access both the English-speaking world and the Chinese-speaking world, but this is not the same case in the U.S. Often, information available in English about China does not provide the full picture. Also as discussed earlier, much of HSS research in China has been published in the Chinese language.
- Culture is another challenge. Here, culture can refer to political culture, traditional culture, social culture, etc. Because of the vast differences between China and the U.S. in all these forms of culture, it could be difficult to fully understand one another; although China is perhaps more familiar with Western cultures than the U.S. is familiar with Chinese cultures. In the previous discussion, I have been tracing back to Chinese history and tradition to provide clearer explanations on issues like academic freedom and the role of HSS; but in fact, almost all issues in contemporary Chinese higher education have historical influences and roots. Some of them seem to be paradoxes, but they are the reality. The existence of paradoxes also challenges binary thinking.
- The final challenge is the complexity of the Chinese higher education and research system. Like the U.S., a great degree of heterogeneity exists within Chinese higher education – such as geographical differences, institutional stratification, disciplinary diversity, and individual variations. This makes it difficult to understand the system comprehensively. Furthermore, Chinese higher education and research are also fast evolving, meaning it would need to be followed closely to understand the whole development trajectory.

Despite the differences, there are many similarities and common grounds shared between China and the U.S., mainly because of China's internationalization of higher education and research. To address the challenges noted above, there might be potential needs in the U.S. government for people who have Chinese language capacity, a good understanding of Chinese culture, the

willingness to learn about a complex and fast-changing system, and the willingness to apply not only the U.S. framework to understand China, but understand China through the China's lenses.

2. It could be helpful to think further about the collaboration and partnerships with China in higher education and research, particularly in HSS research. Regardless of how the U.S.-China relationship unfolds in the future, the two countries are undeniably science giants in the world with close collaboration ties. For example:

- The U.S. and China combined produce 39% of the worldwide science and engineering publications.[37] China is the U.S.' largest collaborator in terms of scientific publications, and vice versa.[38]
- The U.S. is still the top destination for Chinese students who choose to study abroad. Students from China still constitute the largest number of international students in the U.S., many of whom are postgraduate/doctoral students conducting research in the U.S. When they stay in the U.S. after graduation, they form a large group of the high-skilled workforce; and when they move back to China or move to other countries, personal and professional ties with the U.S. would not disappear.[39]

It is acknowledgeable that research collaborations in HSS could face more restrictions and challenges than in STEMM. However, it could still be a loss of opportunities for both China and the U.S., if both sides stop collaborating with each other. As discussed, China's HSS research has been internationalized while keeping Chinese characteristics. This has two implications. First, it is perhaps important to understand that China would keep developing its higher education and research with its own pathway, rather than following entirely Western frameworks. Therefore, Chinese higher education and research would not completely replicate Western patterns. Secondly, it means that the Chinese HSS can contribute to global HSS research with its distinct knowledge and perspectives. Moreover, it would be helpful to note that although academics are influenced by national policies, they are not bounded within national borders, but can operate internationally. If understanding better the seemingly paradoxical situation of researchers, more mutually-beneficial collaborations might be formed on the basis of equality and mutual respect.

[37] US National Science Foundation. (2022). *The state of U.S. science and engineering 2022*. https://ncses.nsf.gov/indicators
[38] Nature Index. https://www.nature.com/nature-index
[39] UNESCO. https://uis.unesco.org/en/uis-student-flow

OPENING STATEMENT OF ANNA B. PUGLISI, DIRECTOR OF BIOTECHNOLOGY PROGRAMS, GEORGETOWN UNIVERSITY CENTER FOR SECURITY AND EMERGING TECHNOLOGY (CSET)

COMMISSIONER CLEVELAND: Thank you. Ms. Puglisi.

MS. PUGLISI: Thank you. Co-Chairs Cleveland and Price, distinguished Commissioners and staff and --- thank you for the opportunity to practice in today's hearing. I'm currently the Director of Biotechnology Programs at the Center for Security and Emerging Technology, or CSET, at Georgetown University, where I lead our Biotechnology efforts and look at China's S&T developments. Previously, I served as a national counterintelligence officer for East Asia and spent about 20 years in the U.S. government as a senior analyst.

Before diving into the specific questions regarding talent and higher education that the -- is the focus of today's hearing, I believe it's essential to address the proverbial elephant in the room when we talk about China, which is whether they're innovative or not, and the assumptions that come along with that, which, first, is that democracy is necessary to be innovative, that China needs a Western development model with --- including venture capital that looks like our, institutions like DARPA, and an efficient market economy. And what we're going to talk about, most of today, that Chinese scientists are not creative or risk takers because of the education system and bureaucracy.

And this is more than a philosophical debate because whether a company, a government, an individual thinks that China is innovative or not impacts the risk calculation that one makes in dealing with China because if you believe, essentially, that you are five or ten years ahead or that you will always out innovate them, you will make a different risk calculation. And that really relates a lot to talent.

And so, my testimony today will first address the policies and programs that China has put in place to grow its national innovation base, especially those related to human capital. In particular, I will discuss how our systems are different and how the role of the state impacts and influences all aspects of China's S&T development and, lastly, offer some lesson learned, which include how China's system really is not the same; that it takes a holistic approach to the development of technology, blurring the lines between public, private, civilian, and military; and that our policies and mitigation strategies need to reflect this reality; that we can't conflate return on investment and commercial success with innovation.

Beijing has shown a willingness to accept inefficiencies to meet its broader goals. And then, finally, that giving scientists a problem to solve is not the same as giving them a solution.

Now, I'm going to talk a little bit about the talent programs. Well, maybe, most of you of probably heard about the Thousand Talent Program. It's just one of hundreds of talents programs that China has initiated to target different age groups and technology areas.

However, the goals are the same, which is to acquire technological know-how needed to support strategic programs and industries as well as train the next generation of scientists and technology and engineers. And that's really an important part, training that next generation. There's too many to name here, so I've provided that in my written testimony but happy to answer any questions.

As for the advantages and disadvantages in China's higher education system, it's important to be clear about what part of that system that we're talking about: undergraduate education or graduate education, STEM or liberal arts, top tier or less well-known -- and we

heard a little bit about that in the first panel --- as each part will have a different impact on China's strategic goals.

And our previous panelists talked about a little bit about that, but some advantages in China's system include, first, the ability to set natural --- national curriculum and prioritize certain technology areas; second, the ability to mobilize all aspects of China's S&T infrastructure to meet the same goal; and lastly, the political will to maintain sustained investment over time.

Some disadvantages include a rigid approach to curriculum and teaching, a highly stratified education system, and a lack of traditional academic freedom. However, I want to emphasize, though, that criticism of China's current education system fails to recognize that factors can be true and untrue, depending on the part of the system that you're talking about. Its top tier can continue to foster military modernization as well as economic development. The lower tier can struggle. They are not mutually exclusive.

I will now turn to the issue of the level of interconnectedness in China's S&T system. It is more interconnected and holistic than the U.S. system, blurring the lines between public, private, military, and civilian. China still has challenges in this area, and our next panelist is going to talk a little bit more about that, but it's made efforts to address this, to --- in its ability to conduct multidisciplinary research in those applications.

I will outline a few here. There's a fuller explanation in my written testimony, but the first is China's State Key Labs system. These are laboratories overseen often by, and collocated with, universities and/or enterprises that receive funding, administrative support, policy development guidance from the China central government. A new policy establishing what they call industrial clusters, these are integrating researchers, developers, and government entities. A lot of them focus on AI and biotechnology. Perhaps China's most well-known policy to do this interconnectedness is its military-civil fusion.

China says it will use any knowledge or technology it acquires for its military. However, increasingly, what we see them focusing on includes things that are not usually thought of as military so Artificial Intelligence, biotechnology, neuroscience, brain-inspired research.

So how does China incentivize its researchers? The Chinese government uses policies and programs to provide a demand signal for certain technology areas. Scientists are given hard problems to solve. The Chinese government supports and invests in these areas. Oftentimes, they'll have longer timelines and smaller return on investments than individual companies can tolerate. 5G, batteries, and DNA sequencing capacity are examples of these.

China's approach to its S&T development may prove unsustainable in the long term, but it can still impact U.S. competitiveness and hurt U.S. interests in the short-term.

So in conclusion, I leave the Committee with the following thoughts. First, China's policies and plans form a complementary web for the development of talent and emerging technologies that can form the foundation for future growth and military modernization that Beijing controls. It's not where they are today in some of these certain fields, but the rate of change that we should really focus on and that building of capacity.

Talent and a robust education system is really essential to compete. Innovation comes from actually do the research. If we don't continue to train our students, technicians, researchers, as well as invest in the tools of discovery, we will not be able to keep pace. And finally, China's policies are challenging for the U.S., its allies, and like-mindeds to counter with policy measures because most policy measures are tactical and not designed to counter an entire system that's different and structurally different.

So I want to thank the Committee for continuing to discuss this issue. These are hard conversations that we as a nation must have if we're going to protect and promote U.S. competitiveness and future developments that reflect our values. We have to start to think about our national innovation base and the talent that support it in terms of the greatest value to the nation as opposed to the lowest cost.

China will gain the advance in the technology competition if we don't identify those areas where national security and market forces diverge and take proactive measures to compete. So thank you very much.

PREPARED STATEMENT OF ANNA B. PUGLISI, DIRECTOR OF BIOTECHNOLOGY PROGRAMS, GEORGETOWN UNIVERSITY CENTER FOR SECURITY AND EMERGING TECHNOLOGY (CSET)

Testimony before the U.S.-China Economic and Security Review Commission hearing on "China's Challenges and Capabilities in Educating and Training the Next Generation Workforce"

Panel II: "Advancing Growth, Knowledge, and Innovation through Higher Education."

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24 February 2023

Co-Chairs Cleveland and Price, distinguished Commissioners and staff, thank you for the opportunity to participate in today's hearing. It is an honor to be here alongside esteemed experts on the different panels. I am currently the Director of Biotechnology programs and a Senior Fellow at the Center for Security and Emerging Technology (CSET) at Georgetown University, where I lead our Biotechnology efforts. For most of my career I have studied China's science and technology (S&T) development and innovation ecosystem, including its efforts to acquire technology and technological know-how, how these efforts have changed over time and the policies and programs China uses to meet its strategic goals.

My testimony today will first address the assumptions that are made about innovation in China, the policies and programs it has put in place to grow its national innovation base–especially those related to human capital–and the implications of these policies for the U.S.-China strategic competition. In particular, I will discuss how our systems differ, and how the role of the state impacts and influences all aspects of China's S&T ecosystem, from universities to its state key labs and its associated industries. I will provide specific examples of how these industry-academia linkages play out in different areas such as AI and biotechnology. Lastly, I'll offer lessons learned, which include:

- Talent development is essential for Beijing to meet its strategic goals and will be a major piece of US-China competition. China has made talent development and acquisition–including leveraging its diaspora–a central part of its technology development and acquisition strategy since the country's "opening" around 1978.
- China's system is not the same. It takes a holistic approach to developing technology—blurring the lines between public, private, civilian and military. Our policies and mitigation strategies need to reflect this reality.
- We must not conflate return on investment (ROI) and commercial success with innovation. Sometimes China's goals are ROI and commercial success, but meeting its strategic goals–even in the commercial area in the short term–does not necessarily mean return on investment or commercial success. Beijing has shown a willingness to accept inefficiencies to meet broader goals. An example of this is its development of 5G and DNA sequencing.
- China will gain the advantage in technology competition if we don't acknowledge and address those areas where national security and market forces diverge.
- Giving scientists a problem to solve is not the same as giving them a solution. Political control is not the same as scientific control. Scientists–and innovation–will thrive with funding, lab space and freedom to pursue their craft.

- Regardless of their personal views, Chinese scientists, businesspeople and officials have to respond to the government or security services if they are asked for information or data. China intimidates and harshly silences its critics—this has only grown more so in the past few years. This increasingly includes its citizens abroad.

Does innovation matter?

How the United States can compete in the 21st century is perhaps one of the most vexing challenges on the minds of policymakers and academics today. The looming challenge of a nation-state keen on dominating the key technology areas of future industries and warfare, paired with an increasingly globalized scientific base, creates unique challenges for the United States beyond what it faced in the Cold War. Human capital is at the center of this competition. However, before diving into the specific questions regarding talent and higher education that are the focus of today's hearing, I believe it is essential to address the "proverbial" elephant in the room when talking about China–do they have the capacity for "true," often inferred as "Western-style," innovation? Underlying this broader debate regarding China's capabilities are a number of assumptions that include:

- "Western-style innovation"—along with democracy—is necessary for "true" innovation
- China needs a Western development model to succeed, including venture capital, institutions such as DARPA and an efficient economy.
- Chinese scientists are not creative or risk takers because of the education system and bureaucracy.

This is more than a philosophical debate because whether a company, government or individual thinks China is innovative or not impacts the risk calculation one makes in dealing with China. This has shaped early interactions and willingness to share technology and train students, researchers and technicians. If you believe you are 5-10 years ahead and you inherently will "always out innovate them" you will make a different risk calculation than if you are dealing with a peer competitor.

Why does this matter? Human capital is the driver of discovery and future industry and increasingly a fundamental part of U.S.-China strategic competition. Xi has called human capital the "first resource"[i] and China's policies reflect this. It is essential to the "art" part of science, manufacturing and other key industries. Tacit knowledge—technological knowhow—is as important as funding and the actual physical technology or data. This is why China, in addition to implementing talent programs to bring back experts to train the next generation of domestic talent, has also focused on maintaining access to U.S. research institutions and universities. China views Western universities as an entry point into the U.S. innovation base.

The way China has implemented this vision since its opening in the late 1970's has changed over time but its goal has remained the same—creating a technically proficient workforce with the right number of "high fliers" to drive weapons programs and new industries. It has accomplished this through a series of central government policies and talent programs that both focus on bringing back experts to drive strategic research programs and training the next generation of Chinese scientists.[ii]

While most of you have probably heard of the Thousand Talents program—it is just one of hundreds of talent programs China has initiated that target different age groups and technology areas. Other central government programs focused on fostering talent and its higher education system include[iii]:

- China's National Medium and Long-term Talent Development Plan (2010–2020). It states that talent is core to the country's social and economic development and sets detailed national talent targets. It also has sections devoted to training of scientists at all levels and how to support an ecosystem where they can thrive.[iv]
- The 2017 "Plan to Build a National Technology Transfer System." This plan highlights the importance of the acquisition of "high-level overseas talent"—both ethnic Chinese scientists from abroad and other foreign scientists.
- The 2016 "Planning Guide for Manufacturing Talent Development." This is a joint plan to import "1000" foreign experts able to make "breakthrough" improvements, via talent programs and other venues. This plan also emphasizes recruiting people from "famous overseas companies."
- The 2004 Chinese Association for Science and Technology's "HOME Program" (or Haizhi Plan, 海智计划)," was instituted to "Help Our Motherland through Elite Intellectual Resources from Overseas," and is supported by China's central and local governments. Its 2019 goals include 29 different projects.
- Talent programs to develop specific high-tech areas such as biotechnology, integrated circuits, and "next-generation" artificial intelligence. Each such program highlights the role it sees for foreign talent such as training, research and mentoring students. [v]

As for the advantages and disadvantages in China's higher education system, it is important to be clear what part of the system we are most interested in—undergraduate education or graduate education, STEM or liberal arts; top tier or less well-known. This is because the advantages and disadvantages will be different across the different segments of its system. There will also be differing impacts on China's strategic goals. Advantages in China's system include:

- The ability to set national curricula and prioritize certain technical areas;
- The ability to direct students to go into different areas of study;
- The ability to mobilize all aspects of the S&T infrastructure, including universities, institutes and companies, to work towards a common goal;
- The ability to use its market to extract help from foreign companies to train and educate students and faculty; and
- The political will to maintain sustained investments over time.

Some disadvantages in China's system include:

- A rigid approach to curriculum and teaching;
- A highly stratified education system with quality dropping significantly outside of the top tiers; and

- Lack of traditional academic freedom.

Criticisms of China's current education system, while in some ways accurate, also fail to recognize that factors can be both true and untrue depending on which part of China's system are focused on. Its top tier can continue to foster military modernization and economic development–including companies that compete with U.S. companies. At the same time its lower tier can struggle–they are not mutually exclusive.

Building an Innovation Foundation: State Key Labs, Industrial Clusters and the Interconnectedness of China's system

China's S&T system is more interconnected and holistic than the U.S. system—blurring the lines between public, private, civilian and military. [vi] One piece of this system that China is developing as a way to foster interdisciplinary research is the State Key Labs (SKL). SKLs play a key role providing the "bridge" over the valley of death and additional training for China's scientists. China's SKL system comprises hundreds of the country's most elite research facilities supported by universities, enterprises, and the Chinese Academy of Science. These laboratories, overseen by, and most often co-located with, universities and enterprises within China, receive funding, administrative support, and policy and developmental guidance from China's central government. They serve as a primary driver of China's strategic basic research efforts and ambitious S&T agenda with both commercial and military applications.

The Chinese government manages most SKLs, but an increasing number of laboratories are run by private companies.[vii] In 2012, the Ministry of Science and Technology (MOST) adopted the "Interim Measures for the Administration of Building State Key Laboratories Relying on Enterprises." The scientific fields prioritized by government and enterprise-run SKLs, according to CSET analysis, differs slightly with government labs prioritizing life and earth sciences and enterprise SKLs placing more emphasis on engineering, information, and materials science. Existing entities can be "promoted" to the title of "State Key Laboratory." They are also beneficiaries of China's state-led talent recruitment programs. A recent CSET publication identified 59 SKLs where 10 percent of personnel (304 individuals) were talent plan awardees.[viii]

Another avenue for interconnectedness is the development of what China calls "industrial clusters" (产业集群). These clusters are focused on promoting multi-disciplinary research and integrating researchers, developers and government entities. China's central government offers funding, space, talent, and other resources to clusters that focus on strategic emerging industries. They consist of small- and medium-sized enterprises in the same or related industry as well as universities, SKLs and larger state-supported enterprises such as BGI and Huawei. [ix]

China's focus on Strategic Emerging Industries is an additional avenue for creating interconnectedness throughout its S&T ecosystem. These policies, the first issued in 2013 and the second issued in 2020, lay a blueprint for its future goals of dominating key sectors through interconnectedness and central planning. These plans focus on securing the China market first on the way to building global champions. Talent plays a key piece in this area.

Finally, China's most well-known policy that fosters interconnectedness is military-civil fusion. China says it will use any knowledge or technology it acquires for its military. This is not conjecture, profiling, or analysis, but China's stated position for decades. From early military-civilian integration (军民结合) policies to the more recent military-civilian fusion (军民融合), China takes a holistic approach to development, blurring what is civilian, what is military, what is private and what is public. This impacts the basis for entry of Chinese students and post-docs into U.S. labs because of China's ability to compel citizens to share information. It also challenges existing export and visa policies that build their restrictions around affiliations with a military end-user but make exceptions for civilian uses.

The "13th Five-year Plan for Military and Civil Fusion"[x] was established in 2017 and focused on emerging technologies. The plan specifically calls for a "cross-pollination of military and civilian technology in areas not traditionally seen as 'national security issues,' such as quantum telecommunication and computing, neuroscience and brain-inspired research," and states that such projects will be supported by foreign outreach initiatives.

China's ability to use its research ecosystem and leverage talent to pioneer novel and foundational innovation and knowledge on the one hand, and helping to diffuse innovations throughout industry and the economy on the other, is mixed. In many areas, developments are still nascent and the impact on the economy is limited. Below are some examples of how these policies have taken hold and the kinds of relationships that have been established:

- BGI Group is a Shenzhen-based gene sequencing company with a global network of more than 200 subsidiaries. The growth and success of BGI demonstrates not only the holistic nature of China's S&T system, combining private and public sectors and the military, but also how sustained support can impact a key emerging industry. Its collaborations give BGI—and China—access to genomic data worldwide.[xi]

- Novogene (诺禾致源科技) is a genomic services provider that claims to have the world's largest sequencing capacity. Its founder, Li Ruiqiang (李瑞强) was a senior executive at BGI and is an expert in genomics. Novogene received investments from state-owned entities including CMB International Capital Corporation, China Merchants Bank, and the State Development and Investment Corp. [xii]

- The Chinese Academy of Sciences Institute of Computing Technology (ICT) combines AI and medical research at its Bioinformatics Research Group (生物信息课题组) housed under ICT's Advanced Computing Research Laboratory, and the Medical Imaging, Robotics, Analytical Computing Laboratory & Engineering (医疗影像机器人与分析计算研究组), a subdivision of ICT's Key Laboratory of Intelligent Information Processing.[xiii]

- Shanghai Jiaotong University's Artificial Intelligence Institute houses a Center for Smart Healthcare (智慧医疗研究中心), which "aims to empower clinical medicine and medical

services with AI technology," researches "new paradigms of human-machine interaction," and develops "deep learning services for clinical diagnosis." The center applies AI to disease prediction and a variety of health-related tasks.

- Nankai University College of Artificial Intelligence (南开大学人工智能学院) hosts the Tianjin Municipal Key Laboratory of Intelligent Robotics (天津市智能机器人技术重点实验室). Research and development (R&D) conducted at this laboratory includes medical and service robotics for surgery and rehabilitation support, brain-computer interfaces, and micro and nano detection for life sciences.[xiv]

This leads us to the questions that the Commission has asked regarding how China uses incentive structures and funding to ensure scientists, researchers and developers' work is in alignment with China's "top-down techno-industrial ambitions" and how it differs from that in the United States. The Chinese government, through a multitude of policies and programs, provides a demand signal for certain technology areas. China's national S&T goals are set by committees under that state council that include all aspects of its S&T infrastructure–these are experts in specific fields that are setting these goals. The policies outlined previously provide blueprints for what the Chinese government prioritizes but does not tell scientists how to solve these problems. Giving scientists a problem to solve is not the same as giving them a solution.

By incentivizing and creating the environment where researchers, developers and producers are co-located, China hopes to be able to fill shortcomings related to commercializing and developing key sectors. This model has proven successful in the past. Bell Labs is one example. As highlighted in Jon Gertner's *Idea Factory*, some of the key advantages that allowed Bell Labs to thrive were: long development timelines, constant funding, and a multidisciplinary environment. [xv] These are the elements China is putting in place through the plans I have just discussed.

China's system is also different because of the role of the state that permeates all aspects of society from Party cells in businesses, including western ones, a Party Secretary at universities, and the social credit system that impacts daily life. Chinese students are sent overseas to learn with a purpose, and its business and S&T collaborations are designed to deliver maximum returns to the state.[xvi] Although Beijing has not always been successful in this endeavor, its strategy illustrates a government with a plan and the political will to take a long-term view of development, invest in infrastructure and people, and put in place the building blocks it needs to support China's economy and military modernization. It is masterful at setting the terms of those engagements to achieve long-term goals determined by the state.

The role of the state also impacts the individual. Regardless of their personal views, Chinese scientists, businesspeople and officials have to respond to the government or security services if they are asked for information or data. China intimidates and harshly silences its critics—this has only grown more so in the past few years. Unfortunately, it also increasingly includes its citizens–scientists, students and business people– abroad, including in the United States.
In comparing our two systems, we must remember that success can look different and also be different. China's approach to S&T development may prove unsustainable in the long-term, but still impact U.S. competitiveness and hurt U.S. interests. It took the Soviet Union 75 years to

fail; in that amount of time China and its market distorting practices can do a lot of harm to the U.S. economy and also continue its military modernization in ways that can impact U.S strategic calculus. There are places where good enough is good enough and when writing a check can impact development timelines or buy your way to the front of a technology field. Perhaps the best explanation for why what China is doing not only works, but undermines the assumptions of the importance of efficiency, is put forth by Kai Fu Lee:[xvii]

> "What these critics miss is that this process can be both highly inefficient and extraordinarily effective. When the long-term upside is so monumental, overpaying in the short term can be the right thing to do. The Chinese government wanted to engineer a fundamental shift in the Chinese economy, from manufacturing-led growth to innovation-led growth, and it wanted to do that in a hurry and the process of pure force was often locally inefficient—incubators that went unoccupied and innovation avenues that never paid off—but on a national scale, the impact was tremendous."

The early stages of development for these new knowledge-based industries–such as AI and biotechnology–will be most critical for government support and policies. These "first-mover" advantages may prove to be so critical that those nations that fail to make similar investments and commitments may have difficulty catching up. This gives centrally funded programs targeting specific new technologies an advantage. An erosion in leadership could constrain Washington's policy options such as the United States' ability to set global technology norms, regulations, and standards, as well as harness and control access to technologies for military purposes. [xviii]

Conclusions:

As we move forward to develop policies to compete with China and foster our own talent development, we must challenge our assumptions of how this should look. China does not need to do things the way the United States has done them and follow the same path to succeed. When formulating policies, it is important to remember that our systems are different and that just because it has a similar name—university, company, court—does not mean it will function the same way ours does. The image of a China forging a unique path that suits its needs at a given time is put forth by Nathan Sivin in his description of post-Mao science, noting that "China has gradually since 1949, by fits and by starts, invented policies towards education and science that reflect its own priorities rather than the expectations of other nations."[xix]

Focusing on extremes in examining U.S.-China capabilities—that innovation can only happen in the private sector and that government has little or no role—ignores the potential levers that policy makers can use to foster and incentivize growth in areas with longer timelines and lower returns on investment than private investors currently tolerate. It also underestimates the impact China's approach can have on its ability to compete and how its efforts can create an unequal playing field and potentially distort developmental timelines because of its heavy hand and proactive involvement. In moving forward, I leave the committee with the following thoughts:

- Innovation comes from doing the research—if we are not doing the research, and cede whole disciplines, we will not be innovative.

- A society cannot be innovative if it isn't training enough students.
- Developing and maintaining big science facilities are essential to the national innovation base.
- It doesn't matter if we did it 40 years ago, if we don't continue to train students, technicians and researchers, as well as invest in the tools of discovery we will not be innovative.
- China's policies and plans form a complementary web of development and industrial policies for emerging technologies—and talent growth—and most importantly build a national innovation base that will be the foundation for future economic growth and military modernization that Beijing controls. It is not where they are today in certain fields, but the rate of change that we should focus on.
- China's policies are increasingly challenging for the United States and its allies to counter with policy measures because most policy measures are tactical and not designed to counter an entire system that is structurally different.

I want to thank the committee again for continuing to discuss this issue. These are hard conversations that we as a nation must have if we are to protect and promote U.S. competitiveness, future developments, and our values. We have to start to think about our national innovation base and fostering domestic talent in terms of what is the greatest value to the nation, not only traditional economic efficiency and lowest cost. China will gain the advantage in technology competition if we don't identify those areas where national security and market forces diverge and take proactive measures to compete.

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[i] State Council, 2017; "Why is Xi Jinping's 'First Resource' so important?" ["习近平眼里的"第一资源"为何如此重要"], *People* [人民网], July 18, 2018, http://politics.people.com.cn/n1/2018/0718/c1001-30155931.html.; 国家技术转移体系建设方案. State Council, 2017; 制造业人才发展规划指南. MOE, MHRSS, MIIT, 2016.

[ii] Hannas et al., "Chinese Industrial Espionage: Technology Acquisition and Military Modernization". Routledge, 2013.

[iii] "十三五" 生物技术创新专项规划 (*13th Five-year Plan for Biotechnology Innovation*). MOST, 2017; 国家集成电路产业发展推进纲要 (National Integrated Circuit Industry Development Plan). State Council, 2014; 新一代人工智能发展规划. (Next-Generation Artificial Intelligence Development Plan). State Council, 2017; "Why is Xi Jinping's 'First Resource' so important?" ["习近平眼里的"第一资源"为何如此重要"], *People* [人民网], July 18, 2018, http://politics.people.com.cn/n1/2018/0718/c1001-30155931.html.; 国家技术转移体系建设方案. State Council, 2017; 制造业人才发展规划指南. MOE, MHRSS, MIIT, 2016.

[iv] "Medium and Long-Term Plan for Science and Technology Development (2006-2020) [国家中长期科学和技术发展规划纲要 (2006—2020 年)], State Council of the People's Republic of China [中华人民共和国国务院], 2006, http://www.gov.cn/gongbao/content/2006/content_240244.htm.

[v] 十三五" 科技军民融合发展专项规划. MOST, CMC, 2017; "十三五" 生物技术创新专项规划 (*13th Five-year Plan for Biotechnology Innovation*). MOST, 2017; 国家集成电路产业发展推进纲要 (National Integrated Circuit Industry Development Plan). State Council, 2014; 新一代人工智能发展规划. (Next-Generation Artificial Intelligence Development Plan). State Council, 2017

[vi] A history of China's investment programs and policies can be found in the following: Simon and CAO "China's Emerging Technological Edge", Cambridge University Press, 2009; Applebaum et al., "Innovation in China", Polity Press, China Today Series, 2018 and Hannas et al., "Chinese Industrial Espionage", Routledge, 2013.

[vii] "Guiding Opinions on Relying on the Transformation of Institutions and Enterprises to Build State Key Laboratories" [关于依托转制院所和企业建设国家重点实验室的指导意见], PRC State Council, 2006, https://perma.cc/6WYG-3SZQ; Yuntao Sun and Cong Cao, "Planning for science: China's 'grand experiment' and global implications," *Humanities and Social Sciences Communications* 8, Article number 215, 2021, https://www.nature.com/articles/s41599-021-00895-7.

[viii] "Notice of the Ministry of Science and Technology on Issuing the Evaluation Results of 99 Enterprise State Key Laboratories" [科技部关于发布 99 个企业国家重点实验室评估结果的通知], PRC Ministry of Science and Technology, 2018, https://perma.cc/4HB3-Y7VQ.

[iv] "The State Administration for Market Regulation on Issuing the Interim Measures for the Administration of State Key Laboratory Market Regulation: Notice of the 'Interim Measures for the Administration of the National Market Supervision Technology Innovation Center'" [市场监管总局关于印发《国家市场监管重点实验室管理暂行办法》《国家市场监管技术创新中心管理暂行办法》的通知],State Administration for Market Regulation, January 8, 2020, https://perma.cc/ZWE5-7JCX; "Chinese State Key Laboratories," Datenna, https://www.datenna.com/chinese-state-key-laboratories/; Fangjuan Yang, Zheng Liang, and Lan Xue, "Assessing the Effects of the Chinese State Key Laboratory Scheme," 2019 Portland International Conference on Management of Engineering and Technology (PICMET), 2019, p. 2, doi: 10.23919/PICMET.2019.8893820.

[ix] PRC National Development and Reform Commission, 加快推进战略性新兴产业产业集群建设有关工作通知 (Notice on Accelerating the Construction of Industrial Clusters in Strategic Emerging Industries), NDRC 1473, 2019.

[x] Translation of "The 13th Five-Year Special Plan for S&T Military-Civil Fusion Development" ["十三五"科技军民融合发展专项规划], Center for Security and Emerging Technology; "Opinions on the In-Depth Development of Military-Civil Fusion" [军民融合深度发展的意见], General Office of the State Council on Promoting the National Defense Technology Industry [国务院办公厅关于推动国防科技工业], December 2017, https://perma.cc/4M58-X4C2; "'Military-to-civilian' and 'civilian-to-military' pace accelerates, the development of MCF continues to release new momentum" ["军转民""民参军"步伐加快军民融合发展持续释放新动能], China Financial News Network [中国金融新闻网], August 1, 2018, https://perma.cc/B4FH-H2SK

[xi] BGI 华大 in Chinese. The Beijing Genomics Institute, forerunner of the BGI Group, began life in 1999 and continues some of its earlier activities in the Chinese Academy of Sciences as the Beijing Institute of Genomics (北京基因组研究所, BIG). We use the term "BGI" interchangeably to refer to the composite entities; *Reuters* reported BGI used a military supercomputer to analyze genetic data obtained from its sales of prenatal tests to map the prevalence of viruses in Chinese women, look for indicators of mental illness, and genetically identify Tibetan and Uyghur minorities. BGI published at least twelve joint studies on the tests with the PLA since 2010. (Kirsty Needham and Clare Baldwin, "Special Report: China's Gene Giant Harvests Data from Millions of Women," *Reuters,* July 7, 2021.

[xii] https://en.novogene.com/about/about-novogene/; "Novogene," https://www.crunchbase.com/organization/novogene-corporation/company_financials.

[xiii] http://bioinfo.ict.ac.cn/; "About Us," http://miracle.ict.ac.cn/.

[xiv] https://ai.nankai.edu.cn/xszx/tjsznjqrjszdsys.htm.

[xv] Co-locating scientist from different disciplines and researchers and developers has been flagged as a key characteristic of building an innovation foundation according to Mervin Kelly, Bell Labs executive and President from 1925 to 1959.

[xvi] Adopted from Hannas et al., "Chinese Industrial Espionage", Routledge 2013.

[xvii] LEE Kai-Fu, "AI Superpowers: China, Silicon Valley and the New World Order" 2018.

[xviii] Mazzucato, Mariana, "The Entrepreneutial State: Debunking Public vs. Private Sector Myths", Public Affairs, 2015.

[xix] Sivin, Nathan from Science in Contemporary China, p.28, ed Leo Orleans, Stanford University Press, 1980.

OPENING STATEMENT OF JEFFREY DING, ASSISTANT PROFESSOR OF POLITICAL SCIENCE, GEORGE WASHINGTON UNIVERSITY

COMMISSIONER CLEVELAND: Excellent. Thank you. Dr. Ding.

DR. DING: Thank you so much, distinguished Commissioners and staff, for having me here and inviting me back. Sometimes, I don't get invited back to things. So I don't know what to make of that, but it's good to be back and hope to be back in the future. Second thing I'm --- sorry. Second thing I'm grateful for is --- especially the staff --- for inviting me to talk about this forthcoming paper that's coming out in the Review of International Political Economy about China's diffusion deficit. And it's very rare for academics to get interest in their papers before they come out, and also after they come out, so I guess it's all downhill from here, in terms of my --- in terms of future papers. But I'm very grateful and excited to talk about it.

So I'm going to talk about four things. First is explaining what I mean by innovation versus diffusion capacity, especially when it comes to why we even care about China's innovation capacity, their human capital, why we care about China's technological capabilities, and how we assess scientific and technological capabilities.

Then, I'm going to talk about why I think China's facing a diffusion deficit, which I define as there's a wide gap between China's ability to produce new technologies and its capacity to spread them across a lot of productive processes.

Third, I'm going to talk about the role of education in that diffusion deficit with some examples from emerging technologies, like AI. And I'll conclude with some policy recommendations.

I'll begin by saying that discussions about national scientific and technological capabilities are often obsessed with which state creates new-to-the-world innovations, who comes out with the first big idea. My argument is that we should spend a lot more time and emphasis on a country's diffusion capacity: its ability to spread and adopt innovations and embed them across a lot of productive processes.

And I think this distinction is really important for general-purpose technologies. These are technologies that economists have identified as historical engines of growth, things that can permeate throughout the entire economy, like electricity or computers or Artificial Intelligence. So it doesn't matter as much, in my opinion, which state produces the first electric dynamo.

It matters much more which state electrifies their economy at scale in a more sustainable and effective way. It doesn't matter as much which state produces the first computer. It matters much more which state computerizes its entire economy. It doesn't matter that much which state produces the first ChatGPT or the first major breakthrough in Artificial Intelligence. It matters a lot more which state intelligentizes its economy at scale. And my argument is that technological capabilities matter when we think about this --- the --- when we think about assessing rising powers because the key part about why all this matters is which country can sustain productivity growth in the long run.

If you look at the historical patterns of the rise and fall of great powers, the countries that became the leaders in power transitions that occurred, they occurred through the mechanism of one great power, one rising power sustaining economic growth at higher rates than their rivals. Britain became the economic leader first, off the back of innovations in the steam engine, and other technologies in cotton textiles.

Germany and the U.S. challenged Britain's leadership in those areas off the back of innovations in electricity, interchangeable manufacture. But they became economic rivals first, and then, the economic power translated into political and military leadership. And so, if we think about the rise and fall of great powers and U.S.-China competition into emerging technologies through this lens of which country can adapt technologies at scale, which countries can build a better a diffusion capacity, I think that reorients the framework by which we evaluate scientific and technological capabilities.

So again, we're trying to measure whether China's capacity to innovate differs strongly from its capacity to diffuse technologies at scale. And I argue that this sort of diffusion deficit does exist. By a lot of measures that are more closely related to innovation capacity, China seems to be among the world leaders. The quality of their top three universities is very high. The quality of their top three firms, in terms of R&D expenditures, is very high.

We've seen a lot of figures saying China's producing more science and technology PhDs than the U.S., in terms of some of the highest leading talent. And there's no doubt that in certain emerging technologies like AI, China's going to be able to produce major breakthroughs. They have strong firms in this space. What my analysis shows is that when you look at how these major breakthroughs are translated and diffused throughout the entire economy, there's a much bigger gap. This requires a focus more on the linkages between those frontier firms --- the Baidus, Alibabas, and Tencents of the world --- to the small and medium-sized firms that need to actually adopt what's coming out of these frontier firms.

And so, my method of doing this was to take the Global Innovation Index, which has a lot of different science and technology indicators, sort them by which ones were closer to innovation capacity and by which ones were closer to diffusion capacity, and look at China's global rankings by those two subindexes.

And on the Innovation Capacity subindex, China's much closer to the U.S.'s rankings. On the Diffusion Capacity subindex, there's a huge gap. And I think we see this with the diffusion of information communication technologies, such as low cloud computing adoption rates.

Third part is to look at what is the role of education in all of this. And I think that, in China's case, there's an overemphasis on R&D. Chinese policy-makers have been very good and effective at meeting R&D targets, much less effective in terms of meeting education targets. And if you compare China's public expenditures on education as a ratio of GDP, that figure is lower than the corresponding figures for Brazil, Malaysia, Mexico, and South Africa, other newly industrializing economies.

We see the complete opposite when it comes to support for R&D and breakthrough innovations. China's much higher than all of those other countries. I also bring to bear some data on the breadth of education institutions that can train everyday engineers.

So in the AI field, if you look at one measure of universities that have at least one researcher that has published in a leading AI venue, leading AI conference or journal, China was home to only 29 universities that met that standard. The U.S. accounted for 159 such universities. So it's not even about --- I'm not looking at the best and the brightest talent.

I'm not that concerned about the universities that are producing the most cutting-edge innovations in AI, just the amount of universities that can provide a baseline of quality AI engineering education. And there's a huge gap between the U.S. and China.

I'm cognizant of time, so I'll conclude --- I'll just point you to the three recommendations I have in the policy recommendations in the written testimony, and I look forward to the discussion.

PREPARED STATEMENT OF JEFFREY DING, ASSISTANT PROFESSOR OF POLITICAL SCIENCE, GEORGE WASHINGTON UNIVERSITY

February 24, 2023

"China's Challenges and Capabilities in Human Capital for General-Purpose Technologies"

Testimony before the U.S.-China Economic and Security Review Commission

Hearing on China's Challenges and Capabilities in Educating and Training the Next Generation Workforce

Jeffrey Ding

Assistant Professor of Political Science, George Washington University

Introduction

This testimony articulates an important distinction between innovation and diffusion capacity, which is crucial to accurate assessments of national scientific and technological capabilities. In contrast to an innovation-centric approach, an assessment based on diffusion capacity reveals that China is far from being a science and technology superpower. China's efforts to reform its education system will play a pivotal role in its ability to adapt to revolutionary technological advances and sustain economic growth in the long run.

I. Innovation vs. Diffusion Capacity

Discussions about national S&T capabilities tend to center on which state first generates new-to-the-world breakthroughs (*innovation capacity)*. In this testimony, the main point I aim to convey is that estimates of China's S&T capabilities should give greater weight to its *diffusion capacity*, or its ability to spread and adopt innovations, after their initial inception, across productive processes. When there is a substantial disparity between these two facets of a nation's S&T capabilities, innovation-centric assessments of its power to leverage S&T advances for sustained economic growth will prove misleading.[1]

Up front, I want to clarify that my testimony is especially relevant for assessments of a rising power's ability to exploit technological changes and maintain higher economic growth rates than its rivals. Historically, this mechanism has been central to the rise and fall of great powers.[2] My testimony has less bearing on other channels by which states can leverage S&T capabilities for influence, which may also come under the committee's purview. Innovation-centric assessments may be rightly prioritized in such contexts, such as the significance of S&T systems to prestige

[1] This and the following section draw on a forthcoming article: Jeffrey Ding. (2023). "The Diffusion Deficit in Scientific and Technological Power: Re-assessing China's Rise." *Review of International Political Economy*.

[2] Kennedy, Paul M. The Rise and Fall of the Great Powers: Economic Change and Military Conflict from 1500 to 2000. New York: Random House, 1987.

and reputation, control over global supply chains, and military power.[3] Still, appropriate attention to diffusion capacity can better inform other S&T dimensions of state power. For instance, there can be a large disparity between a military's ability to first field advanced military systems and its ability to adopt such systems throughout its branches and subunits.[4]

In many cases, there is not much daylight between a state's diffusion capacity and its innovation capacity. These two parameters can be highly correlated. After all, the state that first pioneered a new method has a first-mover advantage in the widespread adoption of that technique. In addition, absorbing innovations from international sources is difficult without the tacit knowledge embedded in the original context of technological development.[5] Diffusion and innovation are entangled, overlapping processes.[6]

However, in some circumstances, diffusion and innovation capacity can widely diverge. Aside from innovation capacity, many other factors can shape a country's adoption rate of new technologies, including institutions that incentivize technology transfer, trade openness, and human capital.[7] The "advantages of backwardness" sometimes enable laggards to diffuse new technologies faster than the pioneering states.[8] Confronting a world of globalized science and technology flows, even the most advanced economies must be able to intensively absorb and diffuse innovations first incubated in other countries. According to one estimate derived from data on Organisation for Economic Co-operation and Development countries, 93 percent of total factor productivity increases in these high-income countries derive from knowledge that originated abroad.[9]

As a result, diffusion capacity indicators can be better predictors of a state's long-term growth trajectory than innovation capacity indicators. The latter may be more unreliable given the uncertain, protracted pathway between a new technology's introduction and its ultimate impact on productivity growth. To this point, one study found that two standard innovation capacity indicators, R&D intensity and patenting rates, tracked less well with subsequent changes in

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[3] Gilady, Lilach. The Price of Prestige. Chicago: Univ. of Chicago Press, 2017, 55-89; Malkin, Anton. "The Made in China Challenge to US Structural Power: Industrial Policy, Intellectual Property and Multinational Corporations." Review of International Political Economy 0, no. 0 (October 1, 2020): 1–33; Paarlberg, Robert L. "Knowledge as Power: Science, Military Dominance, and U.S. Security." International Security 29, no. 1 (2004): 122–51.

[4] Ding, Jeffrey and Allan Dafoe. (2023). Engines of Power: Electricity, AI, and General-purpose, Military Transformations. *European Journal of International Security*, 1-18.

[5] Fadly, Dalia, and Francisco Fontes. "Geographical Proximity and Renewable Energy Diffusion: An Empirical Approach." Energy Policy 129 (June 1, 2019): 422–35; Keller, Wolfgang. "International Technology Diffusion." Journal of Economic Literature 42, no. 3 (September 2004): 752–82.

[6] Taylor, Mark Zachary. The Politics of Innovation: Why Some Countries Are Better Than Others at Science and Technology. 1st edition. New York, NY: Oxford University Press, 2016.

[7] Comin, Diego, and Bart Hobijn. "An Exploration of Technology Diffusion." American Economic Review 100, no. 5 (December 2010): 2031–59.

[8] Gerschenkron, Alexander. "Economic Backwardness in Historical Perspective (1962)." The Political Economy Reader: Markets as Institutions, 1962, 211–28.

[9] Madsen, Jakob B. "Technology Spillover through Trade and TFP Convergence: 135 Years of Evidence for the OECD Countries." Journal of International Economics 72, no. 2 (July 1, 2007): 464–80.

productivity than indicators of activities related to broadly disseminating information about new products and processes.[10]

When there is a substantial gap between diffusion and innovation capacity, assessments based solely on innovation capacity indicators will be misleading because they undervalue the process by which new advances are embedded into productive processes. Specifically, a "diffusion deficit" characterizes situations when a state has a strong innovation capacity but weak diffusion capacity, which suggests that it is less likely to sustain its rise than innovation-centric assessments depict. For example, innovation-centric assessments overestimated the Soviet Union's scientific and technological capabilities in the postwar period. Taking diffusion capacity seriously would have provided a more balanced assessment of the Soviet Union's scientific and technological capabilities.[11]

II. China's Diffusion Deficit

Is China poised to become a science and technology superpower? Existing assessments of China's S&T capabilities tend to center on its aptitude in generating novel breakthroughs. To warn about challenges to U.S. technological leadership, analysts typically cite China's impressive performance in indicators of innovation capacity, such as R&D expenditures, scientific publications, and patents.[12] Less attention, if any, is paid to China's diffusion capacity. For example, the U.S.-China Economic and Security Review Commission's 2022 report to Congress mentions "innovation" 146 times. The term "diffusion" appears just twice.[13]

Yet, according to my research, China faces a diffusion deficit: its diffusion capacity trails significantly behind its innovation capacity. Similar to issues with evaluating the Soviet Union's S&T ecosystem in the 1970s, this means that conventional assessments overestimate China's S&T capabilities. It is necessary to reorient such assessments toward a diffusion-centric lens, which show that China is far less likely to sustain its rise than innovation-centric assessments suggest.

To analyze whether China's diffusion capacity varies significantly from its innovation capacity, I separated indicators included in the Global Innovation Index, a widely-used benchmark for national S&T capabilities published by the World Intellectual Property Organization, into these dimensions. For example, the GII ranks countries globally by the quality of their top three universities and their top three firms' R&D expenditures. I categorize these as indicators of innovation capacity. The GII also ranks countries by indicators that correlate strongly with a

[10] Alexopoulos, Michelle. "Read All about It!! What Happens Following a Technology Shock?" American Economic Review 101, no. 4 (June 2011): 1144–79.
[11] For more on this historical case, see Jeffrey Ding. (2023). "The Diffusion Deficit in Scientific and Technological Power: Re-assessing China's Rise." *Review of International Political Economy*.
[12] Kennedy, Andrew B. "Powerhouses or Pretenders? Debating China's and India's Emergence as Technological Powers." The Pacific Review 28, no. 2 (March 15, 2015): 281–302.
[13] U.S.-China Economic and Security Review Commission. "2022 Report to Congress." November 2022.

country's capacity to diffuse new advances, including the extent of linkages between businesses and universities.

This decomposition of the 2020 GII reveals that China's diffusion capacity significantly lags behind its innovation capacity (Table 1). Using the GII's figures, averaging China's global ranking on indicators for innovation capacity gives an average of 13.8. However, if the same exercise is conducted using diffusion capacity indicators, China's average ranking drops to 47.2. For reference, on the innovation capacity subindex, China's score is very close to the U.S.'s average ranking (11.9). As for the diffusion capacity subindex, the gap widens significantly between China's average ranking of 47.2 and the U.S.'s average ranking of 26.9. Table 1 displays the GII indicators used to calculate China's diffusion capacity and innovation capacity.

A close examination of China's adoption of information and communications technologies (ICTs), key drivers of future productivity growth, provides further evidence of China's lethargic diffusion capacity. While China has been successful at large-scale deployment in a few key domains — consumer-facing applications like mobile payments and high-speed rail — these achievements do not characterize the overall trend in ICTs. Chinese businesses have been slow to embrace digitization, as measured by adoption rates of cloud computing, digital factories, industrial robots, smart sensors, and key industrial software.[14] The International Telecommunication Union's ICT Development Index provides a composite measure of the level of access to and use of ICTs in countries around the world. On this metric, China ranks 83rd in the world, which trails the U.S. by 67 places.[15]

III. Education and Technological Advantage

China's investments in human capital will be a significant factor in shaping its future diffusion and innovation capacity. There is some evidence that the Chinese government prioritizes R&D investments, which sometimes trades off other pathways to productivity growth based around technology adoption and broad-based education.[16] The consistency of China's fulfillment of R&D spending targets does not extend to the fulfillment of education funding benchmarks.

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[14] Alibaba Research Institute. "From Connected to Empowered: Smart+ Assisting the High-Quality Development of China's Economy [从连接到赋能：'智能+'助力中国经济高质量发展]," March 11, 2019; Synced [机器之心]. "Market Research Report on Supply and Demand for Digital Intelligentization Solutions for China's Small and Medium Enterprises [中国中小企业数智化解决方案供应市场研究报告 2020]," October 2020; Techxcope [战略前沿技术]. "Innovation Is More than Invention: Detailed Explanation of the German Industry-University-Research Systems' Big Four [创新不止于发明：德国产学研体系四大金刚详解]," November 18, 2020.

[15] International Telecommunications Union. "Measuring the Information Society Report 2017," 2017. https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2017.aspx.

[16] Brandt, Loren, John Litwack, Elitza Mileva, Luhang Wang, Yifan Zhang, and Luan Zhao. "China's Productivity Slowdown and Future Growth Potential." Policy Research Working Paper. World Bank Group, June 2020.

A comparison of China with other newly industrialized economies illustrates this point. Based on 2018 data, China's public expenditures on education as a ratio of GDP was lower than the corresponding figure for Brazil, Malaysia, Mexico, and South Africa.[17] By contrast, China's R&D spending as a percentage of GDP far exceeded that of these countries. One possible explanation for this disparity, according to a group of experts on China's science and technology system, is the longer time required for efforts in education policy to yield tangible progress in technological development.[18] Related research has shown that the Chinese government has neglected low levels of upper secondary education attainment, possibly due to the over-reporting of such rates by the Ministry of Education.[19]

In recent years, there has been more scrutiny of China's investments in the human capital necessary to adapt to emerging technologies such as AI. As technology races forward, skills must keep pace. Some studies, including a report by Harvard University's Belfer Center for Science and International Affairs, inflate China's capacity to diffuse AI advances at scale because of its sheer quantity of computer science graduates.[20] Accurately assessing China's current strengths and weaknesses in AI education is an important issue.

General counts of graduates, without accounting for the quality of education, overstate China's capacity to cultivate a broad base of AI engineers. Comparisons of computer science education, in particular, can mislead, if the quality of such training is not considered.[21] Consider one quality baseline for AI education: a university meets this standard if it employs at least one researcher that has published at least one paper in a leading AI conference. According to data from the years 2020-2021, China was home to only 29 universities that met this standard; the U.S. accounted for 159 such universities.[22]

When it comes to disseminating AI advances across the entire economy, robust linkages between academic and industry settings are especially crucial. The U.S. has built a strong connective tissue in this respect. Per data on the years 2015 to 2019, the U.S. was the world leader in the number of academic-corporate hybrid AI publications — publications co-authored by at least one researcher from industry and one researcher from academia. This more than

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[17] Statistics based on the UNESCO Institute of Statistics Database.
[18] Liu, Xielin, Sylvia Schwaag Serger, Ulrike Tagscherer, and Amber Y. Chang. "Beyond Catch-up—Can a New Innovation Policy Help China Overcome the Middle Income Trap?" Science and Public Policy 44, no. 5 (October 1, 2017): 656–69.
[19] Khor, Niny, Lihua Pang, Chengfang Liu, Fang Chang, Di Mo, Prashant Loyalka, and Scott Rozelle. "China's Looming Human Capital Crisis: Upper Secondary Educational Attainment Rates and the Middle-Income Trap." *The China Quarterly* 228 (December 2016): 905–26.
[20] Allison, Graham, and Eric Schmidt. "Is China Beating the U.S. to AI Supremacy?" Belfer Center for Science and International Affairs, August 2020.
[21] Loyalka, Prashant, Ou Lydia Liu, Guirong Li, Igor Chirikov, Elena Kardanova, Lin Gu, Guangming Ling, et al. "Computer Science Skills across China, India, Russia, and the United States." Proceedings of the National Academy of Sciences 116, no. 14 (April 2, 2019): 6732–36.
[22] Analysis based on the CSRankings website. For details on the original methodology, see Tencent Research Institute and Boss Zhipin 2017, 12.

doubled China's number of hybrid AI publications.[23] Indeed, China's official state news agency has highlighted the lack of technical exchanges between universities and industry as one of five key weaknesses in China's AI talent ecosystem.[24]

It is now becoming increasingly common for reports to claim that China has overtaken the U.S. in certain measures of elite research in AI.[25] One important distinction to make is that these claims tend to draw on indicators based on AI publications in *journals*. In fast-moving fields like AI, a country's performance in *conference* publications may be a much better indicator of its high-end talent than journal publication-based indicators. As Stanford University's AI Index pointed out in 2021, "the United States has consistently (and significantly) more AI conference papers (which are also more heavily cited) than China over the last decade."[26]

To be sure, China has made important investments in enhancing AI education. In 2018, the Chinese Ministry of Education approved the creation of an AI major, which was quickly adopted by universities around the country.[27] For instance, a February 2021 survey report on China's computer vision talent found that 7 percent of respondents (which included students in the computer vision field) had studied the new AI major. These initiatives followed from the designation of "AI 2.0", an initiative to significantly boost AI education and development, as one of 16 Megaprojects in 2017.[28] Since many of these efforts will take a long time to bear fruit, it is too early to make definitive conclusions about China's efforts to align its human capital investments with its techno-industrial policy aims in AI.

IV. Conclusion and Policy Recommendations

Given the above analysis of China's diffusion and innovation capacity, the following policy recommendations could help safeguard U.S. interests:

First, keep calm and avoid overhyping China's S&T capabilities. My research suggests that the U.S.'s lead in S&T capabilities over China should endure. This committee receives a lot of

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[23] Zhang, Daniel, Saurabh Mishra, Erik Brynjolfsson, John Etchemendy, Deep Ganguli, Barbara Grosz, Terah Lyons, et al. "The AI Index 2021 Annual Report." Stanford Human-Centered Artificial Intelligence Institute, 2021.

[24] Xinhua. "News Analysis: Examining the Five Shortcomings of China's AI Talent System［新闻分析：透视中国人工智能人才体系五大短板]." Xinhua News Agency, August 28, 2019. http://www.gov.cn/xinwen/2019-08/28/content_5425310.htm.

[25] See, for example, Nikkei Asia. "China Trounces U.S. in AI Research Output and Quality." January 15, 2023. https://asia.nikkei.com/Business/China-tech/China-trounces-U.S.-in-AI-research-output-and-quality.

[26] Zhang, Daniel, Saurabh Mishra, Erik Brynjolfsson, John Etchemendy, Deep Ganguli, Barbara Grosz, Terah Lyons, et al. "The AI Index 2021 Annual Report." Stanford Human-Centered Artificial Intelligence Institute, 2021.

[27] Ding, Jeffrey. "China's current capabilities, policies, and industrial ecosystem in AI." Testimony before the US-China Economic and Security Review Commission Hearing on Technology, Trade, and Military-Civil Fusion: China's Pursuit of Artificial Intelligence, New Materials, and New Energy (2019).

[28] Ding, Jeffrey. "Deciphering China's AI dream." *Future of Humanity Institute Technical Report* (2018).

proactive policy proposals. Sometimes the status quo is a defensible policy option. Techno-industrial policy is a difficult endeavor, and there is a risk that even the most agreeable policy interventions can backfire.

Second, revive the Office of Technology Assessment (OTA). There is a need for more balanced assessments of where China and the U.S. stand with respect to S&T capabilities. The OTA helped fill this gap from 1972 to 1995. There is bipartisan support for this proposal, and both liberal and conservative think tanks have supported proposals to revive the OTA.[29]

Third, invest in technology diffusion. In the context of general-purpose technologies such as AI, policies directed at broadening the AI talent base, such as by further supporting community colleges in developing the AI workforce, may be just as, if not more, important as producing the best and brightest AI experts.[30] The U.S. should also invest in "technology diffusion institutions," such as applied technology centers and dedicated field services, that encourage the adoption of AI techniques by small businesses.[31] All too often, it seems, the U.S. government's go-to recommendation for any strategic technology is to boost R&D spending. A diffusion-oriented perspective demands a more varied approach.

Appendix

Table 1: China's S&T Power: An Innovation-Diffusion Decomposition of the GII

Innovation Capacity Subindex		*Diffusion Capacity Subindex*	
Indicator	China's global ranking	Indicator	China's global ranking
QS university rankings	3	ICT access	71
Gross expenditures on R&D	13	ICT use	53
Global R&D companies	3	University/industry research collaboration	29
Researchers, full-time equiv./mn pop.	48	State of cluster development	25
R&D performed by business	12	GERD financed by abroad	81
R&D financed by business	4	JV strategic alliance deals/bn	76
Patents by origin*	1	Patent families 2+ offices/bn PPP%GDP	27
Patent Cooperation Treaty patents by origin*	15	Intellectual property receipts, % total trade	44
Utility models by origin/bn PPP$ GDP*	1	High-tech net exports, % total trade	5
Scientific & technical articles*	39	ICT services exports, % total trade	61
Citable documents H-index	13		
Average ranking	**13.8**	**Average ranking**	**47.2**

Source: Global Innovation Index 2020, World Intellectual Property Organization 2020. *per billion PPP$ GDP.

[29] Katherine Tully-McManus, "House Members Call for Office of Technology Assessment Revival," Roll Call, April 2, 2019, https://www.rollcall.com/news/congress/house-members-call-office-technology-assessment-revival.
[30] West, Darrell M. *The Future of Work: Robots, AI, and Automation*. Brookings Institution Press, 2018, p. 112-113; National Security Commission on Artificial Intelligence. "Final Report." Washington, D.C.: NSCAI, March 2021. https://www.nscai.gov/2021-final-report/, p. 175.
[31] Shapira, Philip, and Jan Youtie. "The next Production Revolution and Institutions for Technology Diffusion." *The Next Production Revolution: Implications for Governments and Business*, 2017.

PANEL II QUESTION AND ANSWER

COMMISSIONER CLEVELAND: Thank you very much. Commissioner Bartholomew, we'll start with you.

CHAIRMAN BARTHOLOMEW: Thank you. Thanks very much again to our witnesses. Trying to figure out where to start. Dr. Ding, I think, in a lot of ways, your testimony takes us right into the elephant in the room that Ms. Puglisi raised, which is -- does freedom of speech --- is innovation possible in a context like the Chinese system, as we understand the Chinese system. But I want to make sure that I understand.

You said that there's a big gap in the ability to diffuse --- and I am presuming, who does that gap benefit? --- and not a big gap in innovation, and I would have thought that that was the other way around. So maybe I'm misunderstanding something. But can you explain that to us more?

DR. DING: Yeah. Thank you for the question. I think when I'm looking at innovation capacity, I'm interested in which countries can produce the novel-to-the-world innovations, which countries have the best chance to produce those innovations. I think by a lot of metrics --- patent metrics, R&D spending, number of highly cited publications that a lot of people cite in the space right now --- China performs very well and is considered a near-peer to the U.S., if not even exceeding the U.S. in some of these innovation capacity indicators.

When I say there's a gap, I'm saying that China performs much less well on diffusion capacity indicators. And I do think that runs counter to the conventional wisdom. I think sometimes we look at what's happening in mobile payments or high-speed rail, and we extrapolate to say that China can adopt anything at scale. I think it's much harder to do so for things that are necessary for businesses to become more productive. So the examples that I cite in the written testimony include things like cloud computing adoption across businesses -- are businesses even using computers; are they online; what is the diffusion rate, adoption rate of those technologies -- the use of industrial software to automate certain processes. All those rates, if you look at those indicators, China's lagging far behind the U.S.

And for me, that diffusion capacity metric is much more important because, historically, the rise and fall of great powers has centered on which country can actually sustain productivity growth in the long run. And actually having these technologies adopted across a lot of businesses in that scale is what's going to be driving productivity growth.

CHAIRMAN BARTHOLOMEW: Interesting. Ms. Puglisi, can I put you on the spot and ask what you think because it sounds like he's --- Dr. Ding is flipping the basic understanding? Perhaps our understanding has been wrong.

MS. PUGLISI: No, actually, I think there's a --- two questions in here is whether or not they can actually create, do the research, have new innovation --- or innovations in the sense of things that are new to the world, and then, how do you translate that. And I think some of the areas that I've talked about -- China's State Key Labs, the new policies around industrial clusters --- are things that the Chinese government are --- is doing to bridge that gap because we've seen -- it's step-by-step, and these are --- a very different kind of skill level.

Oftentimes, I talk about innovation you really need to break down into are we talking about basic research, applied research, commercialization, or putting it into a weapons system. Those are really, really different things, and those are really different skills and so being able to translate all of the investments in R&D into the commercial space to drive different parts of the

economy and how that differs from, Okay, are we talking about things that take longer timelines or things that --- as Dr. Ding is talking about translate into specific companies.

So I'm not sure if that answers your question, but it kind of is both sides of the coin, so you need to kind of really put in place those different parts to be able to capture some of the things that they're doing.

CHAIRMAN BARTHOLOMEW: All right. Thank you. Dr. Xu, interested --- I was interested to hear that --- about the Confucius approach, intellectual approach, and my sense --- again, perhaps incorrectly --- has been that with the implementation of Xi Jinping Thought, that it's permeating universities, and people have less freedom to think or to, at least, speak about what they're thinking.

So can you talk a little bit more what sectors, for example, do you think that Confucianism is --- that the Confucius tradition is still alive in universities? Is it in poetry? Is it in --- where do you still see it existing?

DR. XU: Thank you for the question. It is a really important one because I think during different political eras in China, the extent of academic freedom definitely varies. And in the Xi's China, the limitations and restrictions on academic freedom is seen more often in universities. And in terms of the Confucian values, I think we may be able to say that, in humanities and social sciences, academics may embrace more about the Confucian value -- or not necessarily Confucian value but kind of the intention to contribute to the society and to the nation-building.

So for instance, in many of the Chinese institutions, if academics make policy recommendations and the policy recommendations are agreed upon or assigned by governments at different levels, then that would be considered as important and valuable research outputs. And in some institutions, that would be incentivized. So that speaks more perhaps to humanities and social sciences research.

But this also exists within sciences, like when natural sciences were still in research as well. But as mentioned also in the written testimony, I think it's not only about the Confucian value, it's also about how education research is governed. In China, it's about the incentive structures. It's about the governance. It's about the national --- not just controls but influences on the research directions and values.

CHAIRMAN BARTHOLOMEW: Thank you very much, and thank you to the Co-Chairs of the hearing for their forbearance in letting me go over my time.

COMMISSIONER CLEVELAND: You're welcome. Commissioner Borochoff.

COMMISSIONER BOROCHOFF: Thank you. In reading the testimony from the three of you, I got very, very excited because I could relate to it. I'm going to start with what you just said a moment ago, Dr. Ding, and then ask all of you just for your analysis. It's a little bit related to the first question that Chair Bartholomew asked. In small companies -- and I have lots of experience with this -- there are always innovators.

And all over America, we've seen incredible innovations where somebody comes out with something that eventually leads to tremendous growth. You have --- I don't know if you created the term, diffusion capacity, but in growing my businesses, the various ones that I had, we called it, ability to execute. And so, I think what this comes down to is I have seen --- we've all seen --- incredible innovations.

A guy named Andy Viterbi came out with the Viterbi algorithm, which led to the cell phone. He founded Qualcomm. But you know what happened to Qualcomm was that it got purchased by another company because there was a limit to what he could execute. He made

$120 billion dollars, an incredible amount of money. But the people that ended up --- dominating the cell phone business weren't Qualcomm; it was Apple, if you ask anybody in the world.

The guy who invented the personal computer started Compaq. It's gone; somebody else is doing it. So there's a saying in businesses as they grow that they --- it's better to be the settler than the pioneer, so the question is --- I think there is a little dissonance between what the two of you are saying, and not that you disagree, but I take great solace in what you're saying, Dr. Ding, if it's true, because there are --- if you are correct, it's going to be hard to become executors.

But my question for all of you is: is it your perception that they don't yet have the ability to execute, or is it your perception that maybe they haven't yet done it. Because what we saw America do during World War II, when there was true danger to the whole country, was it became incredible innovators and executors. We did that. And I wonder if that's not what's occurring to some extent in China. So I want your opinions. And Dr. Ding, you can start.

DR. DING: Yeah, I can start. I think, just to bounce off your point of is there disagreement or not, I think part of it is Dr. Puglisi and I are talking about different things. So I think a lot of her written testimony and testimony today was also specifically talking about military-civil fusion and military capabilities. Right? I'm mostly focused on productivity growth, economic productivity growth.

So I think there's a lot of things that our disagreement might just be we're emphasizing different things. I think, for me, your point is correct, that we need both innovation capacity and diffusion capacity, need to have both the innovation and the execution. Right? I think right now I'm trying to derive a bunch of different indicators that would let us measure and assess diffusion capacity.

So one of those is if you have a lot of connective tissue that allow ideas to go back and forth between universities and firms. So one indicator of that is, in the AI space, how many hybrid publications do you have, publications that have at least one author from the business world and one author from the university world? And how close are those ties? And the U.S. leads China by more than double on that metric, according to my written testimony.

So I think you're pointing us exactly where we need to go to --- we need to assess both innovation and diffusion capacity. I think we just have underemphasized the latter, and that's what I'm trying to bring to light.

MS. PUGLISI: Right. I think in my spoken testimony, I emphasized something slightly different. But I think it's also --- it comes back to my comment about the change over time --- right? -- because if we were having this hearing, and I think some -- those of you -- you've heard me speak on this topic before. We were talking about the innovation capacity about ten years ago. We still talk about that.

What we've seen China do, and similarly to how they've put in place the building blocks for that innovation capacity, is now trying to put in place those building blocks for the diffusion capacity. So partly, that is the State Key Labs. Partly, this is a new construct that they call industrial clusters -- where we see universities, companies state supportive, state-owned, being put together, research institutes -- as a way to kind of recreate or create a Bell Labs kind of situation, where you have the people that are thinking thoughts applying those thoughts and pushing because --- and I would also venture to say that finding indicators of what that's going to look like is also challenging because it's the question of do we look at market economy indicators for a nonmarket economy.

And I would venture to say that we have be careful when we do that because success can mean something very different and can look very different in a nonmarket economy. And also, I would venture to say that the emphasis earlier really was on giving some of those innovations a focus on military modernization. And what is lost in the conversation between military-civil fusion is -- oftentimes, it's as much pushing lessons learned and capabilities from the military into the civilian world. And we've seen some of those success stories, such as batteries is a great example of that.

COMMISSIONER BOROCHOFF: Thank you very much.

COMMISSIONER CLEVELAND: Thank you. Commissioner Friedberg, I'll wait until the end so Commissioner Friedberg.

COMMISSIONER FRIEDBERG: Thank you very much. Yes. I think Ms. Puglisi and Dr. Ding really have focused on what seems, to me, to be a core question in all of this. For a long time, people in the West and the United States thought basically that China had to become like us in order to be innovative. But what we've seen so far is that the CCP system has been able to retain political control while, at the same time, in fact, becoming more innovative in various ways.

And the question is what are the implications for the longer term. It seems there might be a way of reconciling what appear to be differences between the two, which have to do with the time horizon. So I think Dr. Ding is talking about the longer term, innovative productive capacity of the economy over decades or centuries. Ms. Puglisi is, I think, pointing to the possibility that in the near-to-medium term, even a system which might, in certain respects, be less efficient and less innovative than ours can still cause considerable problems, challenges, strategic challenges.

So I'd be interested in your views on that, but let me start by asking Dr. Ding, basically, what, if anything, could the CCP regime do to improve its capacity for diffusion and absorption? Would the changes be profound and structural and require some sort of different political arrangements, or is it a matter of adjusting policies here and there?

DR. DING: Thank you for the question, Dr. Friedberg. And I have benefitted a lot from your work on power assessment in framing some of these ideas, so it's great to hear from you. I think, to your point about why do we care about technological capacity and the time frame for these issues --- yeah, I think one of the reasons I wanted to make an intervention in this area is there is a key debate happening among U.S. policy-makers right now, which is which power has time on its side, the U.S. or China. Another key question is who will have --- who has the chance for technological leadership in the next 20, next 10, 10, 20 years. If you talk to people who implemented the October 2022 chip controls on China, they were saying, We are doing these actions because we view this as a long-term competition.

If you --- if your mindset is, Actually, the U.S. is very well positioned in the long term, decades down the line, that might make the status quo and --- a defensible option, which is what I'm trying to emphasize in my testimony. I think I agree to your point that a China that doesn't catch up to the U.S. fully can still pose a lot of problems. There's a lot of research to that extent, and I think that's important to highlight. I'm trying to answer a different question.

In terms of whether --- what the CCP can do to improve its diffusion capacity, I think the aspect of it that's structural is party-planned economies, centrally planned economies are not good at diffusion. They're not natural acting. There's no natural-acting, fast-acting mechanisms for diffusion. We saw that with the Soviet Union. Soviet Union was pumping out more PhD graduates than the U.S., could be quick to produce the first innovation or the first implementation

of something, very slow in terms of diffusing it throughout their entire economy. It's because they weren't a market economy.

So I think that is very much the biggest structural impediment to what degree China regresses toward a more centrally planned economy and to what extent liberalization --- economic liberalization is allowed to continue apace.

COMMISSIONER FRIEDBERG: Okay. Thank you. Ms. Puglisi, if you have thoughts on that, I'd be interested. But I had a specific question, and that is to what extent do you think China's success thus far in moving forward and becoming more innovative has had to do with their continued access to our system and to the broader Western technological, scientific, innovative system. And what would be the consequences of that access being constricted on their ability to be innovative in the future?

MS. PUGLISI: Okay. Thank you. Think I'm going to attempt the first one --- or your --- the --- to respond. I think with the comments about it being centrally planned, there are areas in industries where having the --- being able to follow those longer timelines really make a difference. And I think we saw that with 5G.

But I think different technology areas also have different characteristics and drivers. And so, in areas I believe that really lack legacy --- and I would put biotechnology in that; I'm going to use that as a good case study. We've seen the development over the last two decades of leaders in that field and areas that touch on every aspect of development, from doing the research, from having sequencing capacity to being able to field diagnostic kits and increasingly moving up that value chain and to the point where there are researchers and entities at hospitals all over the world that are dependent on those services.

And so, I think we have to really look industry by industry to see, Okay, where are they ahead? Where is this being implemented better than others or more completely than others? As far as the comment as to how do we --- or how does access to the U.S. system -- the talent piece is really important in that area. And in some ways, the Chinese government really still does view universities and our own research institutes as that entry point to the U.S. innovation system. And that also gets at the capacity piece.

I can draw on some of my own experiences of being in labs that individuals who have had training outside train their students very differently. They ask different kinds of questions. And you see returnees having that kind of impact, but you also see changes in how Chinese scientists and research students are trained, so something as simple as -- for here, we take for granted undergraduates go off and do a research project.

That wasn't always the case. That is the case now at the top-tier universities in China. And so, that tacit knowledge, learning how to do things, getting training, especially at the PhD, post-doctoral level, does have that impact on some of those strategic programs.

COMMISSIONER FRIEDBERG: Thank you very much.

COMMISSIONER CLEVELAND: Thank you. Commissioner Goodwin.

COMMISSIONER GOODWIN: Thank you, Madam Chair. Dr. Ding, I want to talk a little bit about intellectual property rights and the role that a robust and balanced intellectual property system of protections can have on this notion of technology diffusion and on China's efforts to address this diffusion deficit, as you refer to it.

Obviously, intellectual property protections provide incentives for businesses and researchers to invest in research and development. And the protections, in turn, presumably, help facilitate this spread of knowledge through licensing and so forth. Their system --- or the

PRC's approach --- the Chinese Communist Party's approach to intellectual property protections is a little different.

And we hear about a lot of restrictions on licenses for foreign entities and foreign researchers and foreign IP owners, certainly, formalized technology transfer requirements and, in some instances, outright theft. Does this approach to intellectual property actually undermine their efforts to become truly innovative and address this diffusion deficit?

DR. DING: Yeah, I think this is a really good example to show that, sometimes, there is a tradeoff between innovations capacity and diffusion capacity. So if you just take an imaginary country and think about what level of intellectual property rights protection they would ideally want, if you set it really high, that's going to encourage more innovation. Right?

It's going to --- you're going to --- that one company that can capture monopoly profits from becoming the first to come up with this intellectual property. If you set it very low, that is all about, Hey, whenever a new innovation comes, it can spread as fast as possible. Right? And that's going to encourage more diffusion capacity. So I think there's --- you're always trying to find a balance, like to what extent can we manage this trade off.

How open do we want information to flow within the economy, and how much do you want to still incentivize that groundbreaking innovation and for that initial pioneer to be able to capture some profits? Right? So I think we've seen --- to take it back to the specifics, we've seen that China has --- Chinese government, I think, has realized that dynamic you talked about, which is having overly lax intellectual property rights protections might not incentivize enough innovation.

So they've tried to move to reform and boost their intellectual property rights regime, but obviously, there are still a lot of issues with --- related to cyber espionage, legal acquisition of intellectual property rights from foreign firms. And I think that's still a very important issue.

COMMISSIONER GOODWIN: Do you see --- and you touched on there --- but do you see that tension as they try to approach --- to Commissioner Friedberg's question about what sort of policy changes they might make to address this deficit, is there inherent tension between trying to incentivize new-to-the-world innovation versus this spread in addressing this technological diffusion deficit, as you put it? And how do they view striking that balance?

DR. DING: Yeah, I think oftentimes it's not necessarily that there's one person as this rational calculator looking at what's going to be best in the national interest, debating between different options. But I think one area where you see the tension that I mentioned in the testimony is the government has the amount of --- has to divide up its resources, attention, and political capital to different areas, and they've spent more on research and development and much less on education. So it's sort of a broad-based education strategy. And so, I think there is that trade off there, as one example.

COMMISSIONER GOODWIN: Thank you.

COMMISSIONER CLEVELAND: I keep forgetting I have to speak. Commissioner Helberg.

COMMISSIONER HELBERG: Thank you so much. And so, my question is for Mrs. Puglisi. I'd like to build on a question raised by Commissioner Goodwin. Your testimony sheds light on the fact that China's technology advances result in no small measure or, at least, in part, from the hundreds of talent program aimed at leveraging talent from overseas. You mentioned that a recent CSET publication identified 59 State Key Labs, where 10 percent of the personnel or 304 individuals, were talent plan awardees. So my question for you is to what extent would

you attribute China's technology advances to its acquisition harnessing of its overseas talent versus the training of its indigenous workforce versus IP theft.

MS. PUGLISI: I think its S&T growth is the product of all three. And so, if we look back at the policies and programs that China's put in place over the last two decades, it really tells a story. If we go back even to the early 2000s -- or late '90s, 2000s, we start seeing some of those initial talent programs being put in the place and really pushing --- especially in the new areas so AI, biotechnology, materials, those kinds of things.

And it's happened simultaneously, so it's not an if or that. It's a both. So we have the talent programs. We see more investments in universities. And at that same time, we see entire institutes, university departments being stood up that are entirely staffed by returnees that, then, change and train the next generation of scientists. And so, it's a little bit of both. As far as the IP theft, almost all of the S&T, central government programs incentivize technology acquisition. Some of it's --- we've written about legal, illegal, extralegal; a lot happens in the grey area.

And so, it's been part of the growth, but at the same time, there's those domestic investments in these different technology programs. So we can't attribute it all to theft or all to that indigenous investments.

COMMISSIONER HELBERG: Thank you. And Professor Ding, do you have reactions to that?

DR. DING: Sorry. You asked my general reactions to what?

COMMISSIONER HELBERG: To Ms. Puglisi's comments.

DR. DING: I agree, I think. There's --- I think the talent programs have been an effective channel for China to access foreign talent. I think --- my hot take on this is this is what countries do to rise. The U.S. sent their best and brightest to German universities at the end of the 19th century that --- because that's where the best chemicals research was happening. And then, a lot of U.S. returnees set up chemical engineering institutions in the U.S. So I think it's not surprising to me that's happening, but I do think that the role of the state is something that's unique.

And that's sort of important to highlight the role of these talent plans and especially arrangements that require China students to go back and work in China for x number of years after getting education or work experience abroad. I think that's something that stands out for me as unique from the normal development pattern of how countries rise.

COMMISSIONER HELBERG: But would you attribute in equal measure the efforts of the government to grow its technical, indigenous workforce as well as its acquisition of overseas talent to the results that it's been achieving in technology?

DR. DING: I don't know --- I don't have a stance on the exact balance, but I would agree that all of those components play an important role. Yeah. I think that -- I think one thing that's interesting is IP protection has almost --- and sort of like the extralegal, illegal acquisition of IP has almost really fallen off the agenda, at least from a U.S. policy-making standpoint, over the last couple of years, which maybe speaks to, if I were to wager a guess, more --- putting more weight on China's indigenous innovation capacity rather than sort of the reliance on foreign acquisition. But that would just be my guess.

COMMISSIONER HELBERG: Thank you. I yield the balance of my time.

COMMISSIONER CLEVELAND: Thank you. Commissioner Price.

COMMISSIONER PRICE: Yes. Thank you. Ms. Puglisi, you made this statement when talking about Chinese policy and plans, all complementing, that it's not where we are today, but what the rate of change is. Can you comment on what you think the rate of change is?

MS. PUGLISI: Yes. I think my comments for that is that it's looking at, Okay, what are those policies and programs that they're putting in place today that will impact some of these shortcomings? And I was very taken with Dr. Ding's paper because it really gets at the heart of the new policies and programs that we're seeing be put in place continue to emphasize how do we move technology and technological know-how out of the lab and into that commercial space. And there's a lot of discourse around we've made all these investments in R&D. How do we have them translate into --- more into a commercial because we've seen they have had a lot of success in the military area, but how do we then use those things to drive the economy?

And that's going to vary over the different technology areas, whether it's a lack-of-legacy area, such as biotechnology and some other --- advanced batteries, materials, as opposed to things that --- such as chips -- that there's a long history and legacy for that.

COMMISSIONER PRICE: Thank you very much. And Dr. Ding, I want to go to your policy recommendations because I'm very taken with anything that starts by saying, Keep calm, and especially your first and third. Can you address those briefly and what you're thinking?

DR. DING: Yeah, thank you for this opportunity. I think, for me, I come from a policy debate background, so this is what I was obsessed with in high school. And in policy debate, one side defends a plan, and the other side defends the status quo. And for me, with my Option one, I'm defending the status quo. If you agree with my assessments that China faces a diffusion deficit and that China's not poised to overtake the U.S. as a scientific and technological superpower, the status quo becomes a more defensive policy.

So that's sort of --- I think, sometimes --- I think it's important to have these debates because I think this probably goes against some of the conventional wisdom or some of the ideas that circulate around in the city. For me, I just think we overstate China's scientific and technological capabilities. And I've made an argument to that respect.

And so, that points towards, if the U.S. is well-positioned, going back to Dr. Friedberg's question, if the U.S. is well-positioned in the long term in this sort of great power competition, the status quo becomes a more defensible option. I think the third policy option is taking this lens of innovation versus diffusion and translating it to what we emphasize in technology policy. If you look at any U.S. government technology policy and scroll down to the first bullet point of policy recommendations, it's always, Invest in more R&D. And I agree. That's probably a good thing. But it's not the only thing that matters when it comes to technological competitiveness.

And so, for me, it's about investing in technology diffusion institutions, applied technology centers, dedicated field services, different voucher systems that encourage the adoption of new techniques by small businesses. And I think if you circle that back down to the education realm, not just about investing in research universities, building a wider pool of talent, investing in things like community colleges to support a wider talent base for AI talent.

So I think that was my --- that was the thrust of my recommendations in the third bucket, just taking that innovation versus diffusion capacity comparison and seeing, Okay, how does that translate to a more effective technology policy for the U.S.A.?

COMMISSIONER PRICE: Thank you. And Dr. Xu, you talk about the need for education exchange and better understanding each other. Are you talking about some of the traditional education exchange/study abroad types of program, or are you looking anything different or innovative to help ensure populations understand each other?

DR. XU: Thank you for that question. So to build understandings, we can do that by traditional ways, as you've mentioned, like student exchange and student mobility, which has been quite inactive, influenced by the pandemic and lockdowns in the past few years. And for the U.S.-China student exchange, China --- the United States is still the top destination for Chinese students going abroad, and Chinese students still constitute the largest population for international students in the United States. But this is not the other way around.

And then, in addition to traditional student mobility, there are also potentially more collaborations or exchanges among academics and researchers, which have been happening but also, again, have been influenced by the geopolitical tensions between China and the U.S. in the past few years.

And also, in addition, there could be --- because admission, the issues about language, so many information about China or knowledge about China in English may not tell the complete story or the full picture of the Chinese higher education and research.

So it may be helpful to be able to building more translations across languages and to have more students who are academics or people in the United States who can understand Chinese language and Chinese cultures and Chinese societies to be able facilitate such communications because, nowadays in China, in the research-intensive universities, practically every student speaks English. So that means the English-speaking world is much more accessible to China than the other way around.

COMMISSIONER PRICE: Thank you.

COMMISSIONER CLEVELAND: Commissioner Schriver.

COMMISSIONER SCHRIVER: Thank you. And thanks to all our witnesses for excellent statements. Professor Ding, if I could just follow up on the same line of questioning, so I would submit you can keep calm and still act. And I would submit even if the status quo is really in our benefit for now, if it's not a static status quo, that the trajectory can still be of some concern. But your last point in recommendation one is the risks of overreacting or unanticipated negatives associated with acting to try to prolong this diffusion deficit or whatever that might be.

But I was curious what you had in mind. What would your concerns be of overreaction? What is overreaction look like to you?

DR. DING: I think that's a good question. I think, in terms of overreaction, things that I'm drawing on are that historical case study with U.S. assessments of Soviet Union scientific and technological capabilities. And in those cases, there were things like this illusory notion of a missile gap, and sort of when you have tensions between great powers, the risks of overreaction are things like inadvertent escalation.

When there is a crisis and you're very worried about another country's capabilities, that might lead to a higher risk of escalation. I think one thing that's -- what, for me, the --- another risk of overreacting is if the U.S. pivots too strongly to almost a containment strategy for China. I think that could --- I think one thing that we almost understate now is the risk of a weak China might be even more great for U.S. national interests.

Potentially, pushing China's economy too far down could lead to diversionary war on part of China, could lead to more unstable situations in the South China Sea. So those are just some of the things that I see, in terms of misperceptions and miscalculations potentially spiraling to conflict escalation.

COMMISSIONER SCHRIVER: Thank you. Ms. Puglisi, thank you for your submission. I like the way how you described the nature of the challenge, that a system overall can have difficulties, challenges, deficits, in terms of innovation, but if there are certain areas of

excellence or focus that are targeted, it can result in kinds of innovation that have direct application in the military space and the like.

And I think that's a very useful way to think about this. But I also sensed, in your statement, your assessment of the trajectory. China can do this with all these challenges and problems that it has, as Professor Ding described. And the trajectory they're on, if I heard you correctly, it should be of great concern to the United States, that we're not doing things to thwart this targeted innovation or -- I don't want to put words in your mouth -- but how you described it.

Am I capturing your statement correctly? And if so, what would the key things be in your mind in terms of dealing with military-civil fusion, thwarting that innovation model? Is it the talent programs, cracking down on that? What may it be?

MS. PUGLISI: So I think I'm not as, maybe, pessimist as Dr. Ding, but I think it's looking at what are those key pieces that China is putting in place that not --- it's not necessarily going to drive today's industries but those industries in the future. And so, that really gets at some of those big science facilities. It's looking at capacity building.

And that --- those investments are something that takes time to play out and -- because I think a lot of the things that we're talking about today, where China has been successful, are the result of policies that they've put in place 10, 20 years ago, especially the talent programs. And that's not to say they're 20 feet tall. That's never what I'm saying or that we need to contain.

It's a question of -- especially in some of these new industries that are going to drive the future, things that we can't even think about right now --- that the focus should be: do we want some of these new technologies developed with our values or with China's? And do we want them to control some of these areas? And -- especially in the one we talk a lot about, AI.

We talk about biotechnology, but in thinking through, Okay, the race from genotype to phenotype, or what genes do, and how that can be used for good and drive medicine, and how do we deal with a changing climate and all through those areas. But then, of course, the flip side is how some of those technologies can be used in the hands of an authoritarian government that in ways that we --- aren't consist with our values.

And so, it's really kind of thinking through what are those investments. And it's just not the amount of money but thinking strategically about what are those tools of discovery. How do we continue to grow because if we just run in place, China's not running in place. And so, really kind of thinking through how do we foster that technology --- or the talent. And that's not just at the PhD level.

And I'm --- I remember I was very taken with some of the earlier comments because that's --- what does it mean to be --- have a technically proficient workforce? And that's not just PhDs. That's --- coming back to the biomanufacturing, a lot of those plants, those are jobs that you don't need a PhD or sometimes even a bachelor's degree for.

But you do need a level of technical proficiency. And it's thinking through, Okay, how do we build that resiliency into our own system as well as thinking through what are those technology areas that we don't want to be dependent?

COMMISSIONER CLEVELAND: Commissioner Wessel.

COMMISSIONER WESSEL: Thank you. I probably have an hour of questions, which I will squeeze into a short time. This is very helpful, and Ms. Puglisi, good to see you again. Thank you for your prior service. You still have a lot of fans in your former places you served, so I share their good wishes. I want to challenge a bit of this, and Mr. Ding, my first visits to China were in the mid '80s, early or mid '80s. And you talk about diffusion.

I think of this as adaptation and system integration. At that time, I visited Beijing Jeep, where the cars were being pushed around by four workers on a dolly because they didn't have integrated manufacturing, etcetera. There were a lot of kits. I visited the McDonnell Douglas, now part of Boeing, where aircraft were being produced, and we were teaching China how to integrate and, I would argue, how to adapt and, in part, how to enable diffusion.

So I think --- I guess my questions go to not about your question about are we trying to contain? My concern is are we enabling? The administration appears ready to do an outbound investment screening mechanism, something this Commission has supported, in concept, because of what types of U.S. --- what U.S. capital is going to support adaptation, diffusion, whatever you want to call it. Ms. Puglisi, you were on the receiving end of talent programs, etcetera, where gaps in Chinese capabilities were often being filled by U.S. capabilities, either through our education systems, through acquisitions like Complete Genomics, back in whenever it was -- 2012, 2013 -- and a lot of other things.

China has every right to expand its economy, to be a great nation, which it is. The question is what are we doing to advance the CCP's goals, both in education, which we're talking about, but also Mr. Ding, in terms of supplying the capabilities, integration enhancements -- I would argue what we did to allow Huawei into our market early on with its pricing techniques gave them diffusion capabilities --- keeping a blind eye to the standard-setting approach that China was pursuing.

So I'm going to stop. Sorry. What's your response to that? What should --- are we enabling China, the CCP's activities, and what --- if we are, what steps should we be taking, if any, to address it? Mr. Ding, do you want to start?

DR. DING: Yeah, let me just say two quick things and then over turn over the balance of the time. One is I think the question is --- first is this is not a two-player game. If we stop enabling or if we stop connections to China, other countries will fill in. And so, I think that's important to understand is that we're not doing a two-player game here, that we have to calculate whether cutting off access to China just allows other countries and other firms to fill in the gap.

I think the second is to compete in a world of globalized innovation networks, you sometimes have to enable other countries. At the same time, you benefit from them enabling you. So it's hard for companies to compete on the global scale without access to talent bases around the world. China has one of the strongest talent bases in science and technology, so that's why U.S. firms are trying to tap into that talent base.

So for me, it's not a question of can you keep China from --- can you cut off China access from the U.S. innovation environment. It's how do you keep the U.S. innovation environment as open as possible, knowing that, every now and then, you're going have to let some flies in, but you're going to run faster than the other side. So there's are two ---

COMMISSIONER WESSEL: I don't see a lot of Chinese entities doing research in the United States, but the amount of U.S. R&D spend and participation still is high. COVID set it back, but our staff did a paper based on commerce data, looking at the rate of spend on R&D, and it continues to increase by U.S. multinationals in China. So I don't think it's a two-way street.

DR. DING: I think --- what I say is the multinationals spending money on research in China, they're not doing it out of charity. They're not doing it to help China. They're doing it because they think that's best for their business and for their firms to be competitive. Microsoft research in Asia, yes, helps China's innovation base, but it also helps Microsoft greatly.

And if you look at talent flows, actually that brings a lot people who become fellows at Microsoft Research Asia in Beijing and brings them to the U.S. innovation ecosystem as well. So they're not doing it out of charity. It is a two-way street for them.

COMMISSIONER WESSEL: Yeah, it's profit, but that's okay.

MS. PUGLISI: Okay, thanks. That is a --- it's a really difficult question, and I think, for me, it comes to looking at do we treat China as a neutral actor --- right? -- because I think the hope was that China, as it got richer, more capable, that it actually would change and acquiesce to global norms and the global norms of commerce. And that's not what we've seen. I want to double back the questions about IP.

We see --- it can be a --- they can put in place IP laws that support their own developments and companies yet at the same time, not respect the technology or not apply them as equally to foreign firms. And in some cases, that's what we're seeing. So understanding that they need to foster that kind of competitiveness within their own ecosystem but, at the same time, not protecting Western IP.

But it really comes down to transparency and reciprocity in the benefits, and, yes, a lot of companies make that deal that they have to --- to be --- to compete, they have to be in the China market and make concessions that they wouldn't make in other places.

But I guess it also comes down as is it a level playing field --- right? -- when our companies or researchers are competing with those that are supported by a nation state that don't have to make market-based decisions because they have those support. Or on the flip side, they don't get access to the market in China as the same way, or that market is used --- market access is used to gain technology and that tacit knowledge.

And to look back at, Okay --- and a great example of this --- if we --- we can find examples all the way around the development cycle. But in, say, areas related to genomics research, just recently, there are papers that are being published in Western journals where the sequences are not being published. And there's a statement --- there's a little kind of caveat that, Well, this is not allowed because the Chinese government does not allow the export of its own genomic data or some of the sequencing information, so we're not sharing it. We're giving you a summary of that. And that's not --- those are not adhering to the global norms of collaboration. And so, it's a slippery slope, I think.

And where --- to --- do --- working with our friends and like-mindeds and allies on --- because they face the same challenges as well. Their companies have to compete and sometimes on an unlevel playing field. And so it's like, How do we work together to ensure that market competition, competition fairness? That's really what it comes down to.

COMMISSIONER WESSEL: Thank you.

COMMISSIONER CLEVELAND: Mr. Wong.

VICE CHAIRMAN WONG: Dr. Ding, I've looked at your index for diffusion, and with the caveat that I don't know how you weight the various factors, it does seem very ICT-heavy. So my question for you is does this diffusion index or this theory of diffusion deficit apply to aerospace, material science, biotech, agricultural science, energy production beyond the ICT realm?

DR. DING: Yeah, I think what I would say is there's a reason why I focus on ICT. ICT, information and communications technologies, just adoption of computers by businesses, those are things that are going to affect every single industry. What happens in the ICT field affects aerospace. It's going to change how anything related to aerospace production, services is going to function.

An innovation in aerospace is not going to change how the IT --- how the ICT field operates. And that's the difference between a general-purpose technology and just an industry, where you're only concerned about market shares. General-purpose technologies, like ICTs, have the ability to usher in waves of productivity growth and allow countries to sustain productivity growth in the long run.

So that's why I focus on ICT. I think you'll see similar dynamics, potentially, in other fields, but the --- why I focus on computers, information and communications technologies --- and I think this is going to be relevant for AI, which is what everyone is talking about right now. AI --- the potential for AI is not because people are going to make a bunch of profits from the AI industry. It's going to be because AI's going to transform how aerospace is done, how all these other manufacturing fields are going to be done. So having these diffusion capacity indicators for these particular technology fields is really important.

VICE CHAIRMAN WONG: Just to follow up on that, going to your recommendations about --- or your recommendation about technology diffusion institutions that are government sponsored, is there a historical track record of that being successful, at least in the United States?

I can see the argument for -- as well as historical examples of U.S. government investment in basic research, but moving to the application of foundational technologies or of revolutionary technologies -- or at least I'm not aware of historical examples of that being needed. And in fact, it might be a drag on our private sector-driven system of decentralized firms discovering and refining use cases and then expanding it where it actually produces value. Is that --- is there a historical precedent? Is this actually a good idea is basically what I'm asking?

DR. DING: Yeah, I think the most important government policy for U.S. technology capacity in history was the Morrill Act, and it expanded the amount of land-grant universities in the late 19th century. And many of those land-grant universities focused on just engineering education, technical education, broadening the base of mechanical engineers, chemical engineers in the U.S. at the time.

And in that historical period, Germany, Britain, they were producing more Nobel Prize winners than the U.S. They were capturing the majority share of publications and patents, cutting-edge innovations in chemicals and all these other technology fields.

U.S. was far from the scientific frontier, but the U.S. became the world's most productive economy in that period because, I think, they developed a wider engineering base that was connected to scientists. It was connecting scientists and entrepreneurs and developing a wide base of engineering skills related to general purpose trends, like mechanization and the spread of interchangeable manufacture in the U.S. So for me, I think there historical antecedents to some of these pushes that I'm making.

VICE CHAIRMAN WONG: And those still existing land-grant colleges are not attuned to the coming foundational technology, whatever term you want to use?

DR. DING: Yeah, I think we have institutions in place. I think part of it is there's always going to be a lag between new technologies and how different institutions can catch up. So the role for the government, for me, is to what extent can it step in and help with that lag where the skills are still racing up to where the technology's going.

VICE CHAIRMAN WONG: Thank you. Do you want to add something? No? No. I thought you -- oh, okay.

MS. PUGLISI: I can, if you ---

VICE CHAIRMAN WONG: No, no. I thought you were raising your hand.

MS. PUGLISI: Oh, no, no. I was --- if you were turning to me.

COMMISSIONER CLEVELAND: He was, so ---

MS. PUGLISI: So I would just add I think there are a lot of historical examples of where government investment has driven the diffusion. We can go back to that time period that Dr. Ding was just talking about with agriculture because looking at some those first investments in agriculture and bringing that back to be planted here in the U.S.

But I'll jump to maybe more recent times. We look at the Manhattan Project. We look at the space program. Those were all massive programs, and the spin offs from those resulted in all kinds of different industries. And we look at, still, the investments in our national laboratories, and the technology that comes out of that, that's actually through CRADAs and other examples that are spun off into a lot of small companies.

So I don't think we can underestimate the impact that those investments have in that foundational pieces.

VICE CHAIRMAN WONG: Maybe this is a --- there's a definitional, not issue, but question here of what is basic research and what is applied. Right? So anyway, thank you.

COMMISSIONER CLEVELAND: At the risk of annoying my colleagues because we are about to go on lunch break, I will submit questions for the record. They will focus on what skills you see are really important at these labs because this is an education and training hearing, and so, I'm --- I will look forward to questions for the record on those issues.

So with that, I think we'll take a 30-minute break and be back for the final panel. Thirty --- I don't know. It's in the schedule how long we're allowed. And thank you very much to the witnesses, really helpful, informative. I learned a great deal. So thank you all.

(Whereupon, the above-entitled matter went off the record at 12:30 p.m. and resumed at 1:07 p.m.)

PANEL III INTRODUCTION BY COMMISSIONER REVA PRICE

COMMISSIONER PRICE: Welcome back, everyone. We're going to begin our third panel. Our third panel, we'll use case studies of China's AI and semiconductor focused talent policies to investigate how China's education system supports strategic and emerging industries.

We'll start with Dahlia Peterson, who is a Research Analyst at the Center for Security and Emerging Technology. Ms. Peterson will discuss the education system's role in advancing artificial intelligence.

Then we'll hear from Dr. Denis Simon, Clinical Professor of Global Business and Technology at University of North Carolina's Kenan-Flagler Business School. Dr. Simon will assess China's education policies to promote semiconductors.

Thank you all very much for your testimony. I ask all our witnesses to please keep their remarks to seven minutes to preserve time for questions and answers. Ms. Peterson, we'll begin with you.

OPENING STATEMENT OF DAHLIA PETERSON, RESEARCH ANALYST, GEORGETOWN UNIVERSITY CENTER FOR SECURITY AND EMERGING TECHNOLOGY (CSET)

MS. PETERSON: Co-Chairs Cleveland and Price, distinguished Commissioners and staff, thank you for the opportunity to testify on how China's education system is training its artificial intelligence workforce.

Today, I will assess how China's strategic plans place talent at its core and shape its AI education system. I'll then close with four recommendations for how the U.S. can increase its own AI talent competitiveness.

China is well aware of the importance of AI talent in fueling its ambitions and has also noted that it has key talent shortages. In 2020, China's Ministry of Human Resources and Social Security released a report that quantified an AI talent gap of more than five million workers, with only one person for every ten openings for AI engineers and technicians.

That report also stated that without progress, the talent gap could exceed ten million by 2025. To tackle this talent shortage, China has relied on several AI education specific government plans which I detail in my written testimony.

Notably, China has taken a holistic approach to AI education. Its national AI strategy defines AI education with the inherently interdisciplinary AI+X model.

This is designed to cross integrate AI plus another subject or the X, and that includes technical topics such as math, computer science, and biology, but also explicitly includes sociology and law.

As a direct response to these plans, the Ministry of Education mandated AI in high school curricula in 2017 and standardized an undergraduate AI major in 2019. This is now offered at over 440 universities and is China's most popular new major.

Universities have also launched more than 50 AI institutes. These tallies exceed the plan's goals to have at least 100 AI majors and 50 AI institutes by 2020.

Many of China's most elite universities offer the AI major, including all of the ivy league equivalent C-9 League and all of the Seven Sons of National Defense.

However, 2022 diverges from this elite trend. With a few exceptions such as Peking University, the 95 institutions that added the AI major in 2022 were mainly lower tier, including multiple vocational colleges in rural areas.

While this could expand China's AI talent pipeline, it also runs the risk that China's centralized push could lead to widespread implementation, but insufficient instructional resources. This risk is especially pronounced in under-resourced areas, which could produce underwhelming results.

Beyond the undergraduate level, another strategic plan calls for increasing the number of graduate students studying AI, especially at the doctoral level. This plan also, quote, highly encourages industry partnerships.

It asks leading AI companies to train university instructors in the latest cutting-edge methods, for company researchers to have double employment at universities, create joint R&D labs and certification trainings, and host entrepreneurship and skills competitions.

To cite just one example of industry partnerships, voice recognition giant iFlytek, which is on the U.S. entity list for human rights violations in Xinjiang, has partnered with public colleges and universities to launch several AI colleges across China. Students are able to work directly with engineers on iFlytek's voice recognition and translations projects.

I'll close by examining implications. CSET has found that since the U.S. education system is highly decentralized, it has a much less uniform approach to AI education than China. The U.S. is also currently prioritizing computer science education more than AI.

While CS is an essential component of training talent to potentially perform AI work, China has shown that it is a step ahead through its incorporation of CS education into formalized AI study programs.

These programs are designed to include some of the latest cutting-edge AI research findings and are directly informed by partnerships with leading Chinese AI companies.

Furthermore, CSET research has also shown that despite China's two decades of talent recruitment drives, nationals either do not return or do so part-time, mostly due to wariness of working in China and potentially confronting workplace politics.

A recent science study found that for those that do return through the Youth Thousand Talents Plan, recruits are of high caliber and show a productivity bump due to larger access to funding and research resources in China. However, their performance is still outdone by top caliber scientists who chose to reject these participation offers.

Meanwhile, immigration retention has been a core U.S. strength, with 91 percent of top Chinese students with U.S. AI doctorates still in the U.S. five years after graduating. Long-term stay rates are also high.

So, amid ongoing strategic competition with China across dimensions, including AI, the U.S. has several crucial opportunities to advance its own AI education and workforce pipelines.

So, I will close by providing a set of four recommendations for how the United States can boost its own AI talent competitiveness, and these recommendations are:

First, starting at the secondary school level, U.S. education should evolve its focus from computer science education to additionally incorporate AI and increase partnerships with industry to bring expertise into the classroom.

Second, the National Institute of Standards and Technology, or NIST, should work with U.S. industry to establish standards for AI and AI-related certifications similar to the process it coordinated for cyber education.

Third, the Office of Personnel Management should establish hiring criteria for federal AI and AI-adjacent jobs that are based on work portfolios and certifications.

And fourth, Congress should provide increased funding to the National Science Foundation's Innovative Technology Experiences for Students and Teachers, also known as ITEST. ITEST should increase the number of AI education initiatives to develop K-12 students' interest in relevant career paths.

Thank you again for the opportunity to testify before the Commission on this important topic and I look forward to taking your questions.

PREPARED STATEMENT OF DAHLIA PETERSON, RESEARCH ANALYST, GEORGETOWN UNIVERSITY CENTER FOR SECURITY AND EMERGING TECHNOLOGY (CSET)

Testimony before the U.S.-China Economic and Security Review Commission

Hearing on "China's Challenges and Capabilities in Educating and Training the Next Generation Workforce"

Panel III: The Role of Education in Promoting China's Strategic and Emerging Industries

Dahlia Peterson
Research Analyst, Center for Security and Emerging Technology (CSET),
Georgetown University

February 24, 2023

Co-Chairs Cleveland and Price, distinguished Commissioners and staff, thank you for the opportunity to testify on how China's education system strives to train a workforce for strategic and emerging industries. It is an honor to be here alongside esteemed experts on this panel. I will detail how China is using a slate of centralized plans to develop its artificial intelligence (AI) education system and assess the effectiveness of measures responding to these plans, which includes the Ministry of Education's work to standardize an AI major across 440 universities, along with the launch of more than 50 university AI institutes. I will close with some of the risks that these developments pose to the United States and provide here a set of four recommendations for how the United States can boost its own AI talent competitiveness. These recommendations are:

1. Starting at the secondary school level, U.S. education should evolve its focus from computer science education to additionally incorporate AI, and increase partnerships with industry to bring expertise into the classroom.

2. The National Institute of Standards and Technology (NIST) should work with U.S. industry to establish standards for AI and AI-related certifications, similar to the process it coordinated for cyber education.[1]

3. The Office of Personnel Management (OPM) should establish hiring criteria for federal AI and AI-adjacent jobs that are based on portfolios of work and certifications.

4. Congress should authorize increased funding to the National Science Foundation's (NSF) Innovative Technology Experiences for Students and Teachers (ITEST). ITEST should increase the number of AI education initiatives to develop K-12 students' interest in relevant career paths.

[1] Diana Gehlhaus, Luke Koslosky, Kayla Goode, and Claire Perkins, "U.S. AI Workforce: Policy Recommendations" (Center for Security and Emerging Technology, October 2021), https://cset.georgetown.edu/wp-content/uploads/CSET-U.S.-AI-Workforce-Policy-Recommendations.pdf.

China's Strategic Approach to AI

China's prioritization of, and progress in, AI has raised concerns in the United States and beyond—and rightly so, for several reasons. Key national security considerations include that this may further advance China's military-civil fusion (MCF) efforts, which could threaten U.S. national security if these efforts increase Chinese military competitiveness. The United States has been particularly concerned about the risks posed by the People's Liberation Army's (PLA) increasing prioritization and purchases of AI-enabled military technology, which China has stated it intends to use to gain "asymmetric advantages" (非对称) in a potential conflict with the United States.[2] Additionally, China's advancements in technologies including computer vision and voice recognition have led to mass AI surveillance of Uyghurs, Tibetans, and indeed anyone within China's borders, including foreigners.[3]

AI talent is the core driver of China's AI progress. The United States must thoroughly understand this landscape in order to lead in AI workforce competitiveness, and to nurture and retain the world's best and brightest.

The Chinese Party-state's strategic approaches to AI technology and industry are laid out in key documents including, but not limited to:

- National 13th Five-Year Plan for the Development of Strategic Emerging Industries (2016–2020, 十三五"国家战略性新兴产业发展规划)
- July 2017 New Generation AI Development Plan (AIDP, 新一代人工智能发展规划)
- 14th Five-Year Plan (2021–2025, 中华人民共和国国民经济和社会发展第十四个五年规划纲要).[4]

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[2] Ryan Fedasiuk, Jennifer Melot, and Ben Murphy, "Harnessed Lightning" (Center for Security and Emerging Technology, October 2021), https://cset.georgetown.edu/publication/harnessed-lightning

[3] Dahlia Peterson, "Designing Alternatives to China's Repressive Surveillance State" (Center for Security and Emerging Technology, October 2020), https://cset.georgetown.edu/publication/designing-alternatives-to-chinas-repressive-surveillance-state; Conor Healy and Donald Maye, "Punishing Journalists PRC Province's Latest Mass Surveillance Project, Won by Neusoft Powered By Huawei," IPVM, November 29, 2021, https://ipvm.com/reports/henan-neusoft; Cate Cadell, "China harvests masses of data on Western targets, documents show," *The Washington Post*, December 31, 2021, https://www.washingtonpost.com/national-security/china-harvests-masses-of-data-on-western-targets-documents-show/2021/12/31/3981ce9c-538e-11ec-8927-c396fa861a71_story.html.

[4] Translations available at: Original CSET Translation of "National 13th Five-Year Plan for the Development of Strategic Emerging Industries," [国务院关于印发"十三五"国家战略性新兴产业发展规划的通知], Central People's Government of the People's Republic of China, November 29, 2016, https://cset.georgetown.edu/publication/national-13th-five-year-plan-for-the-development-of-strategic-emerging-industries; Graham Webster, Rogier Creemers, Paul Triolo, and Elsa Kania, "Full Translation: China's 'New Generation Artificial Intelligence Development Plan' (2017)," *New America*, August 1, 2017, https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017; Original CSET translation of "Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035," [中华人民共和国国民经济和社会发展第十四个五年规划和 2035 年远景目标纲要], Central People's Government of the People's Republic of China, March 12, 2021, https://cset.georgetown.edu/publication/china-14th-five-year-plan.

These documents emphasize the importance of AI to China's national competitiveness and socioeconomic development, and contain aspirational goals that are both qualitative and quantitative. Qualitative goals range from high level to more granular (e.g., becoming the world's "primary AI innovation center" by 2030 as well as prioritizing research in computer vision, human-computer interaction, and intelligent decision control). Quantitative goals laid out in the AIDP for 2020, 2025, and 2030 set targets for the size of AI's core industry as well as the scale of related industries.

Within these strategic plans, the Chinese government explicitly highlights the key role that talent plays in supporting its AI techno-industrial ambitions. For example, the AIDP called for implementing AI training at every level of education, applying AI across all education levels, training a new generation of AI talent, and constructing an AI discipline through the establishment of an AI major and AI institutes.[5] Today, China's AI education starts early at the primary school level, and since 2018, the Ministry of Education has mandated AI to be part of high school information technology curricula.[6] Further goals include understanding AI safety and security, and an emphasis on AI ethics. There is also a distinct emphasis on "learning to abide by relevant laws," which could shape students learning about AI in ways that are most amenable to the Party-state's needs.

Several policies and initiatives that have emerged after the AIDP have been key to AI education implementation. These include, but are not limited to:

- Ministry of Education (April 2018): AI Innovation Action Plan for Colleges and Universities (高等学校人工智能创新行动计划)
- Ministry of Education, National Development and Reform Commission, and the Ministry of Finance (January 2020): Several Opinions on Using "Double First Class" Universities to Promote Disciplinary Integration and Accelerate Training of Graduate Students in the Field of Artificial Intelligence (关于"双一流"建设高校促进学科融合 加快人工智能领域研究生培养的若干意见)

[5] State Council of the People's Republic of China, "The New Generation Artificial Intelligence Development Plan" [新一代人工智能发展规划], July 8, 2017, https://web.archive.org/web/20170721053549/http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm; translated by Graham Webster, Rogier Creemers, Paul Triolo, and Elsa Kania, "Full Translation: China's 'New Generation Artificial Intelligence Development Plan' (2017)," *New America*, August 1, 2017, https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017.

[6] Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, "AI Education in China and the United States" (Center for Security and Emerging Technology, September 2021), https://cset.georgetown.edu/wp-content/uploads/CSET-AI-Education-in-China-and-the-United-States-1.pdf; Chinese Ministry of Education, "The Ministry of Education Issues the 'General High School Curriculum Program and Curriculum Standards for Chinese Language, etc. (2017 Edition)" [教育部关于印发《普通高中课程方案和语文等学科课程标准（2017 年版）》的 通知], December 29, 2017, https://archive.ph/RirvZ.

The "AI Innovation Action Plan" called for several goals to be met by 2020, such as the launch of 50 AI research centers or institutes, and the creation of 100 "AI+x" majors.[7] The AIDP defines the inherently interdisciplinary "AI+x" model as one that is designed to cross integrate professional education for AI plus another subject (the "x"), including mathematics, computer science, physics, biology, psychology, sociology, law, and other disciplines."[8] This demonstrates China's desire to incorporate non-STEM field perspectives to form a more holistic approach to AI education. As detailed below, my research shows that China may have exceeded both of these goals: China has launched more than 50 AI institutes, and 440 universities offer a standardized AI major; however, it is unclear how many of these universities explicitly incorporate the interdisciplinary "AI+x" approach.

The "Accelerate Training of Graduate Students" plan calls for increasing the number of graduate students studying AI, especially at the doctoral level, by using the "Double First Class University" (双一流大学) initiative. This is a 2017 program under Xi Jinping that superseded previous reforms such as Projects 211 and 985 to create "world-class" universities and leading "first-class" disciplines.[9] The "Double First Class" plan was updated in February 2022 to bring the tally to 147 universities.[10] The "Accelerate Training of Graduate Students" plan furthermore stated that AI will be incorporated into the "Special Enrollment Plan for the Cultivation of High-level Talents in Key Fields Urgently Needed by the State" (国家关键领域急需高层次人才培养专项招生计划).[11]

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[7] Chinese Ministry of Education, "AI Innovation Action Plan for Institutes of Higher Education" [高等学校人工智能创新行动计划], April 2, 2018, https://web.archive.org/web/20180420032740/http://www.moe.gov.cn/srcsite/A16/s7062/201804/t20180410_332722.html. Full CSET translation available at: Original CSET Translation of "AI Innovation Action Plan for Institutions of Higher Education", [教育部关于印发《高等学校人工智能创新行动计划》的通知], Ministry of Education, April 2, 2018,https://cset.georgetown.edu/wp-content/uploads/Notice-of-the-Ministry-of-Education-on-Issuing-the-Artificial-Intelligence-Innovation-Action-Plan-for-Institutes-of-Higher-Education.pdf
See an MOE "interpretation" document: Chinese Ministry of Education, "The Ministry of Education Interprets the "AI Innovation Action Plan for Institutions of Higher Education" [教育部解读《高等学校人工智能创新行动计划》], June 8, 2018, https://web.archive.org/web/20180712013232/http://www.moe.gov.cn/jyb_xwfb/xw_fbh/moe_2069/xwfbh_2018n/xwfb_20180608/mtbd/201806/t20180611_339062.html.

[8] State Council of the People's Republic of China, "The New Generation Artificial Intelligence Development Plan" [新一代人工智能发展规划], July 8, 2017, https://web.archive.org/web/20170721053549/http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm; translated by Graham Webster, Rogier Creemers, Paul Triolo, and Elsa Kania, "Full Translation: China's 'New Generation Artificial Intelligence Development Plan' (2017)," *New America*, August 1, 2017, https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017.

[9] Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, "AI Education in China and the United States" (Center for Security and Emerging Technology, September 2021), https://cset.georgetown.edu/wp-content/uploads/CSET-AI-Education-in-China-and-the-United-States-1.pdf.

[10] Zou Shuo, "'World-class' universities list expanded," *China Daily*, February 15, 2022, https://perma.cc/2349-EYP4; full updated list and the key disciplines available here: Chinese Ministry of Education, "List of Higher Education Institutions and Key Disciplines for the Second Round of "Double-First Class" [第二轮"双一流"建设高校及建设学科名单], 2022, https://perma.cc/K7Q9-ZA7L.

[11] Chinese Ministry of Education, National Development and Reform Commission, and Ministry of Finance, "Certain Opinions on Promoting Curricula Merging at "Double World-Class" Institutes of Higher Education and on

Additionally, the "Accelerate Training of Graduate Students" plan places a strong emphasis on partnering with industry, stating that university-industry partnerships are "highly encouraged."[12] It proposes a revolving door between industry and academia, asking that leading AI companies train university instructors in the latest cutting edge methods, and allowing company researchers to have "double employment" at universities. It places an emphasis on going beyond the theoretical and preparing talent to advance AI industry progress by asking AI companies to train graduate students and design "scenario-driven, application-oriented" courses that focus on solving industry needs. Training can include joint construction of projects through industry alliances, creation of joint R&D labs, entrepreneurship and skills competitions, and certification trainings.

Assessment of AI Education Initiatives

In response to these plans, the Ministry of Education (MOE) standardized an AI major in 2019.[13] Figure 1 in the Appendix shows the numbers of majors approved each year, which as of 2022 stands at 440 universities. This includes all of the Ivy League-equivalent C9 League (as identified by the Chinese government in 2009), as well as all of the Seven Sons of National Defense. The Seven Sons are universities directly supervised by the Ministry of Industry and Information Technology (MIIT), and their core mission is to support China's defense research and military-civil fusion.[14]

The fact that all Seven Sons have the AI major is notable given their defense-focused mission. The aforementioned "Double First Class" plan is designed to further mesh these seven universities into the military-civil fusion R&D pipeline, and therefore originate innovations—including in AI—that help both the military and civilian sectors.[15] Further, all of the Seven Sons

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Accelerating the Cultivation of Graduate Students in the AI Field" [关于"双一流"建设高校促进学科融合加快人工智能领域研究生培养的若干意见], January 21, 2020, https://archive.vn/f7iGx; full CSET translation available at: Original CSET Translation of "Notice on the Publication of "Certain Opinions on Promoting Curricula Merging at 'Double World-Class' Institutes of Higher Education and on Accelerating the Cultivation of Graduate Students in the AI Field" by the Ministry of Education, the National Development and Reform Commission, and the Ministry of Finance" [教育部 国家发展改革委 财政部印发 《关于"双一流"建设高校促进学科融合 加快人工智能领域研究生培养的若干意见》的通知], The PRC Ministry of Education (教育部), National Development and Reform Commission (NDRC; 国家发展和改革委员会；发展改革委；发改委), and Ministry of Finance (财政部), January 21, 2020, https://cset.georgetown.edu/publication/notice-on-the-publication-of-certain-opinions-on-promoting-curricula-merging-at-double-world-class-institutes-of-higher-education-and-on-accelerating-the-cultivation-of-graduate-students-in-the.

[12] Ibid.

[13] Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, "AI Education in China and the United States" (Center for Security and Emerging Technology, September 2021), https://cset.georgetown.edu/wp-content/uploads/CSET-AI-Education-in-China-and-the-United-States-1.pdf.

[14] The Seven Sons include the Beijing Institute of Technology, Beijing University of Aeronautics and Astronautics (Beihang), the Harbin Institute of Technology, Harbin Engineering University, Northwestern Polytechnical University, Nanjing University of Aeronautics and Astronautics and Nanjing University of Science and Technology.

[15] Audrey Fritz, "How China's military–civil fusion policy ties into its push for world-class universities," The Strategist (blog) on Australian Strategic Policy Institute, May 19, 2021, https://www.aspistrategist.org.au/how-chinas-militarycivil-fusion-policy-ties-into-its-push-for-world-class-universities.

universities offer the AI major, and about half have AI institutes. Previous CSET research has found that three-fourths of graduates recruited by Chinese defense state-owned enterprises are from the Seven Sons, raising concerns that those equipped with AI skills and capabilities are directly entering the defense workforce.[16] CSET research headed for publication later this year has found that the PLA and defense-affiliated universities are also actively seeking technical AI talent through Chinese job posting boards.

China also exceeded its goal of having at least 50 AI institutes. My non-exhaustive, ongoing tally currently includes 18 AI research institutes (人工智能研究院) and 36 AI colleges (人工智能学院), with four universities hosting both. Research institutes include a mix of talent training, basic research, and applied research for direct industry applications, while AI colleges are more focused on education than research. Slightly over half of the 36 AI colleges offer the AI major, otherwise they offer majors that are AI-adjacent, such as Data Science and Big Data Technology.

In terms of quality, there is a high representation of AI majors, AI institutes, or both, at China's elite universities. Elite universities include the Double First Class universities, the Seven Sons of National Defense, and the C9 League. However, with a few exceptions (such as Peking University), the 95 institutions that added the AI major in 2022 were mainly lower tier, including multiple vocational colleges in rural areas. While this could expand China's AI talent pipeline, it also runs the risk that China's centralized push could lead to widespread integration of AI education, but with poorly designed curricula and insufficient instructional resources. This risk is especially pronounced in under-resourced areas, which could produce underwhelming results.

CSET research has shown that China's STEM education system has been very effective in producing a large number of PhD graduates, while the quality of PhD education is steadily improving.[17] The quantity of such graduates is especially stark when compared to the lower number of STEM PhDs produced by the United States. By 2025, CSET projects that Chinese universities will produce over 77,000 STEM PhD graduates yearly, versus approximately 40,000 in the United States.[18]

For AI education specifically, the undergraduate AI major itself may be too new to concretely measure whether or not it is adequately plugging up workforce shortages, since the 35 programs approved in 2019 will only begin graduating students later this spring, and enrollment numbers for these programs are often neither publicized nor broken out in official education statistics. It is worth noting that beyond the AI major, there are 34 other majors created between 2016–2021 that involve "intelligence" (智能) across engineering, agriculture, and medical fields—these may

[16] Ryan Fedasiuk and Emily Weinstein, "Universities and the Chinese Defense Technology Workforce" (Center for Security and Emerging Technology, December 2020), https://cset.georgetown.edu/wpcontent/uploads/CSET-Universities-and-the-Chinese-Defense-TechnologyWorkforce-1.pdf.
[17] Remco Zwetsloot, Jack Corrigan, Emily Weinstein, Dahlia Peterson, Diana Gehlhaus, and Ryan Fedasiuk, "China is Fast Outpacing U.S. STEM PhD Growth" (Center for Security and Emerging Technology, August 2021), https://cset.georgetown.edu/publication/china-is-fast-outpacing-u-s-stem-phd-growth.
[18] Remco Zwetsloot, Jack Corrigan, Emily Weinstein, Dahlia Peterson, Diana Gehlhaus, and Ryan Fedasiuk, "China is Fast Outpacing U.S. STEM PhD Growth" (Center for Security and Emerging Technology, August 2021), https://cset.georgetown.edu/publication/china-is-fast-outpacing-u-s-stem-phd-growth.

also help to plug AI workforce gaps.[19]

How autonomous are universities?

In developing China's AI talent, the influence of government policy has been paramount in setting standardized high school and undergraduate AI curricula. However, universities do possess some autonomy in shaping the content of their AI research. Accordingly, China's AI education is most influenced by three factors. Ranked in order of importance, these are government policy, universities' access to talent and know-how—from both their own professors' expertise and the AI companies with which they have partnerships and talent exchanges—and lastly, student demand.

First, in terms of government policy, the State Council calling for their establishment in the AIDP formed the catalyst for their widespread adoption nationwide. Indeed, it is commonplace to find university AI institute websites mentioning the AIDP and the "AI Innovation Action Plan" as reasons for their creation.[20] Only a few universities had AI programs and institutes prior to the "AI Innovation Action Plan" and the AIDP.

Likewise, since the AI major is a standardized engineering major approved by the MOE under the code 080717T, there are certain curricula designs and learning objectives built into the major. A Chinese AI company called KXCY AI working with several elite Chinese universities suggests that the AI major's goals are to meet national economic and technological development needs, develop knowledge of basic AI theories, and learn R&D skills, among others.[21] Furthermore, colleges and universities with existing AI programs were encouraged by the MOE in 2018 to expand their scope to establish "AI+x" majors.[22]

Second, while universities primarily launched university AI institutes and applied to the MOE to offer the AI major due to central government AI policies, institutes are slightly more operationally independent compared to the AI major. This is because the major has more set curriculum building blocks, as it is MOE-approved, whereas institutes pursue avenues of AI research largely based on staff and academic expertise. Another influencing factor is partnerships with industry. While it is possible that university-industry partnerships are formed because they are "highly encouraged" in plans such as "Accelerate Training of Graduate Students," the companies' areas of expertise can significantly drive the content of those collaborations.

For example, voice recognition giant iFLYTEK—which is on the U.S. Entity List for human rights violations in Xinjiang—has partnered with public colleges and universities to launch

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[19] "Beyond the hype, what is the true potential of AI-type majors?" [热度背后，人工智能类专业究竟前景如何？] Gathering Intelligence Community (blog) [集智社群], August 25, 2022, https://perma.cc/2NZ2-868R.
[20] Example from Dalian University of Technology's School of AI (focused on graduate research) at "About Our Institute" ["学院概况], Dalian University of Technology, https://perma.cc/V4SD-EMF6.
[21] "Learning path and talent training model for AI major (080717T)" [人工智能专业（080717T）学习路径及人才培养模型]，广州跨象乘云软件技术 [Guangzhou Kuaxiang Chengyun Software Technology], January 25, 2020, https://archive.ph/8Hpo0.
[22] Xiaozhe Yang, "Accelerated Move for AI Education in China," ECNU Review of Education 2, no. 3 (September 2019).

several AI colleges across China. They include Chongqing University of Posts and Telecommunications (CUPT), Chongqing Technology and Business University, a vocational college in Chongqing, and an AI translation-focused institute at the Chongqing Nanfang Translation College Sichuan International Studies University.[23] Students are able to work directly with engineers on iFLYTEK's voice recognition projects.

Third, student demand could be another less influential driver, but this is less explicitly measurable as a reason for why universities create institutes or apply to the MOE to offer the AI major. One indicator is that students (and parents) have seen how AI development has taken China by storm. Accordingly, it has been the most popular AI major since 2020.[24]

Ongoing Challenges

Ongoing talent shortages are commonly reported by Chinese ministries, universities, companies, and other sources in critical AI and AI-adjacent areas such as AI R&D, semiconductors, and cybersecurity. Articles and reports cite employer surveys and the large numbers of unfilled vacancies in these fields, similar to in the United States.[25]

China's government ministries are aware of domestic talent supply shortages, and have quantified them. In 2020, China's Ministry of Human Resources and Social Security (MOHRSS) released a report that quantified an AI talent gap of more than 5 million workers, with a domestic supply/demand ratio of 1:10 (0.1), meaning there is only one person for every 10 openings for AI engineers and technicians.[26] This talent is defined by MOHRSS as "engineering and technical personnel engaged in the analysis, research and development of artificial intelligence–related algorithms, deep learning and other technologies, and design, optimization, operation and maintenance, management and application of artificial intelligence systems."[27] That report also

[23] "My A.I. Chongqing: iFLYTEK's Mountain City Covenant" [我 A.I.重庆：科大讯飞的山城之约], iFLYTEK, September 14, 2020, https://perma.cc/TK82-6VAM The CUPT-iFLYTEK AI college was launched in 2018, with expected enrollment of 1,200 undergraduate students and 900 graduate students by 2020. See "Chongqing Morning Post: CUPT and iFLYTEK jointly established the School of Artificial Intelligence" [重庆晨报：重邮、科大讯飞联合成立人工智能学院]， February 8, 2018, https://perma.cc/N3MA-S2S2.

[24] Zou Shuo, "AI now most favored major at universities," *China Daily*, March 3, 2021, https://archive.ph/jKNYz.

[25] See "China's top talent trends for 2020: tech innovation to drive job market," Hays, https://www.hayschina.cn/en/press-release/content/-2020-?s=d3d3LmhheXMuY24=; A. J. Cortese, "China's Tech Pivot (Part II): STEM Talent Shortage Stymies Core Innovation?" Macro Polo, May 10, 2022, https://macropolo.org/chinas-tech-pivot-stem-talent-shortage; China Information Security Evaluation Center (中国信息安全测评中心), "Research Report on the Status of China's Information Security Professionals (2018–2019)" (中国信息安全从业人员现状调研报告［2018- 2019］年度)," translated by CSET at: Original CSET Translation of "Research Report on the Status of China's Information Security Professionals (2018-2019)" [中国信息安全从业人员现状调研报告（2018-2019 年度）], China Information Technology Security Evaluation Center , September 6, 2019, https://cset.georgetown.edu/publication/research-report-on-the-status-of-chinas-information-security-professionals-2018-2019.

[26] Chinese Ministry of Human Resources and Social Security, "New Occupations — Analysis Report on Artificial Intelligence Engineers' Current Employment Status", [新职业—— 人工智能工程技术人员就业景气现状分析报告], April 30, 2020, https://archive.ph/Dvk4p.

[27] Ibid.

stated that if talent development is not strengthened, the talent gap will exceed 10 million by 2025.

Another 2020 report, from China's Ministry of Industry and Information Technology's (MIIT) Talent Exchange Center, used internally collected data and data from the Chinese jobs platform BOSS (直聘, or Zhipin) to look specifically at the supply/demand ratios for AI-specific positions. It defined critical shortages as anything less than 0.4, or fewer than 4 people per 10 jobs available.[28] They found shortages across the board. This included ratios of 0.37 for AI chip engineers, 0.23 for machine learning engineers, 0.2 for natural language processing engineers, 0.13 in algorithm research positions and 0.17 in application development positions. In some fields this dipped below 0.1, with 0.09 for computer vision engineers and 0.08 for intelligent speech engineers. These latter statistics are particularly striking given Chinese companies' prominence in applications such as facial and voice recognition. Overall, these statistics help put into context why China is prioritizing plugging up these gaps with AI major programs and institutes.

Implications for the United States

CSET has found that by nature of the decentralized education system in the United States, compared to China this country does not have a uniform approach and is prioritizing computer science (CS) education.[29] While CS is an essential component of training talent with the knowledge, skills and abilities to potentially perform AI work, China has shown it is a step ahead through its incorporation of CS education into formalized AI study programs. These programs are designed to include some of the latest cutting edge AI research findings, and are directly informed by partnerships with leading Chinese AI companies.

However, it is far from a foregone conclusion that China will "win" the race for AI talent. In fact, both countries face persistent structural challenges. These include the rural-urban divide, equitable access to quality AI education, and teacher quality.[30]

However, China also faces several unique structural issues that could impact its ability to compete in the longer term. These issues include an aging and now shrinking population due to declining birth rates from failed policies to boost births.[31] This may affect China's ability to produce STEM talent at its current high rate.

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[28] Ministry of Industry and Information Technology Talent Exchange Center (工业和信息化部人才交流中 心), "Artificial Intelligence Industry Talent Development Report (2019-2020 Edition)" [人工智能产业人才发 展报告（2019-2020 年版）], translated by the Center for Security and Emerging Technology (CSET) at https://cset.georgetown.edu/publication/artificial-intelligence-industry-talent-development-report-2019-2020-edition.

[29] Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, "AI Education in China and the United States" (Center for Security and Emerging Technology, September 2021), https://cset.georgetown.edu/wp-content/uploads/CSET-AI-Education-in-China-and-the-United-States-1.pdf.

[30] Ibid.

[31] Alexandra Stevenson and Zixu Wang, "China's Population Falls, Heralding a Demographic Crisis," *The New York Times*, January 16, 2023, https://www.nytimes.com/2023/01/16/business/china-birth-rate.html

Furthermore, CSET research has shown that despite China's two decades of talent recruitment drives, nationals either do not return or do so part-time, mostly due to wariness of working in China and confronting its workplace politics.[32] A recent *Science* study found that for those that do return through the Youth Thousand Talents Plan (YTTP), recruits are of high caliber and show a productivity bump due to larger access to funding and research resources in China.[33] However, their performance is still outdone by top caliber scientists who chose to reject participation offers.[34]

Meanwhile, immigrant retention has been a core U.S. strength, with 91 percent of top Chinese students with U.S. AI doctorates still in the United States five years after graduating.[35] Long-term stay rates are also high: in 2017, about 77 percent of the international STEM PhDs from U.S. universities between 2000 and 2015 were still living in the United States.[36]

Amid ongoing strategic competition with China across dimensions including AI, the United States has several crucial opportunities to advance its own AI education and workforce pipelines. Incorporating AI education into existing CS initiatives while developing AI job competency and certification standards would add valuable clarity and direction to U.S. efforts.

Thank you again for the opportunity to testify before the Commission on this important topic. I look forward to taking your questions.

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[32] Remco Zwetsloot and Dahlia Peterson, "The US-China Tech Wars: China's Immigration Disadvantage," The Diplomat, December 31, 2019, https://thediplomat.com/2019/12/the-us-china-tech-wars-chinas-immigrationdisadvantage.

[33] Dyani Lewis, "China's Thousand Talents Plan to entice researchers home boosted their output," *Nature*, January 5, 2023, https://www.nature.com/articles/d41586-023-00012-5; Dongbo Shi, Weichen Liu, and Yanbo Wang, "Has China's Young Thousand Talents program been successful in recruiting and nurturing top-caliber scientists?" *Science* 379, no. 6627 (January 2023): https://www.science.org/doi/10.1126/science.abq1218.

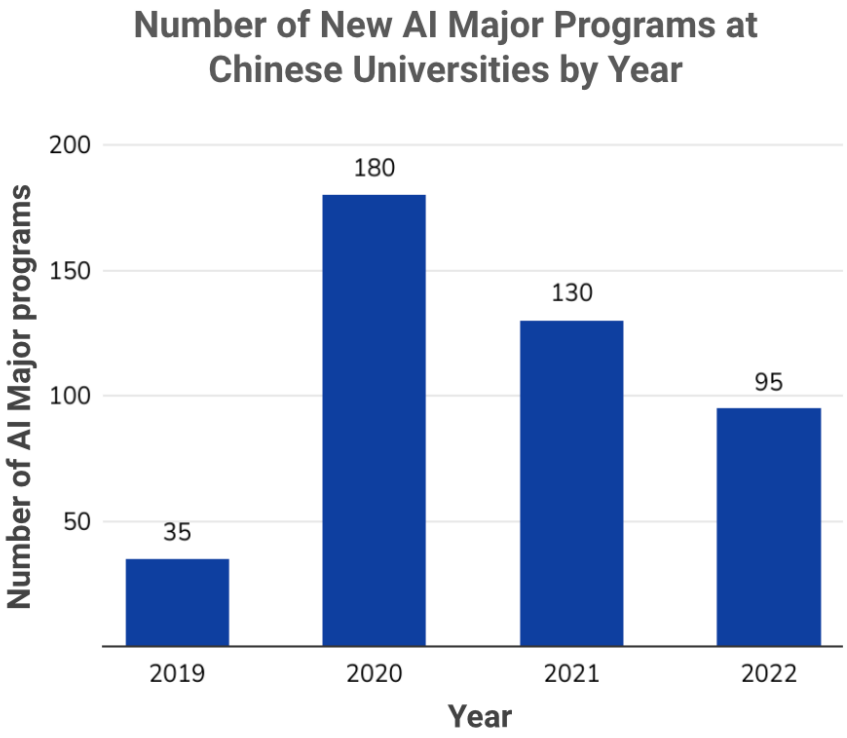
[34] Ibid.

[35] Remco Zwetsloot, James Dunham, Zachary Arnold and Tina Huang, "Keeping Top AI Talent in the United States: Findings and Policy Options for International Graduate Student Retention" (Center for Security and Emerging Technology, December 2019), https://cset.georgetown.edu/wp-content/uploads/KeepingTop-AI-Talent-in-the-United-States.pdf.

[36] Jack Corrigan, James Dunham, and Remco Zwetsloot, "The Long-Term Stay Rates of International STEM PhD Graduates" (Center for Security and Emerging Technology, April 2022), https://cset.georgetown.edu/publication/the-long-term-stay-rates-of-international-stem-phd-graduates.

Appendix

Figure 1: Number of AI Majors Offered Nationally, 2019–2022



Source: Chinese Ministry of Education

OPENING STATEMENT OF DENIS SIMON, CLINICAL PROFESSOR OF GLOBAL BUSINESS AND TECHNOLOGY AT THE KENAN-FLAGLER BUSINESS SCHOOL AT UNC CHAPEL HILL

COMMISSIONER PRICE: Thank you. Dr. Simon?

DR. SIMON: Thank you. Let me too thank the Commissioners for providing an opportunity to speak before you. I'm going to talk today about the training, education, and deployment of semiconductor and IC talent in China.

In 2021, the semiconductor industry grew about 20 percent, with revenues rising to about $590 billion. With that kind of growth, it will soon become a $1 trillion industry, and that kind of growth with a few bumps is anticipated in the future.

Overall, it's safe to say that the entire semiconductor industry is faced with the same challenge, namely to recruit and attract, as well as develop and retain the qualified talent needed to sustain the industry in the years ahead.

The search for talent, therefore, is a significant issue among all parts of the semiconductor industry. China's situation is particularly difficult because it is playing a catchup role as it tries to respond to the increasing number of restrictions placed by the U.S. government and its allies.

Simply stated, without a sustainable pipeline of high caliber talent, China's goals for the semiconductor sector, especially in terms of further indigenization, will not be achievable.

Today, China accounts for about a 35 percent share of the global semiconductor market, making it the one economy with the single largest share of that market.

Its efforts to develop more and more elements of the semiconductor value chain are driven not only by its internal demand, but also right now by the clear recognition that with the imposition of new stringent controls by the United States, the country's only hope to meet its growing demand for advanced semiconductors must come from domestic sources.

The situation regarding the supply and demand of talent for the PRC's semiconductor and IC sectors is rather complex because of the suddenness with which the pressures for indigenization have increased. A range of bottlenecks have emerged, many of which are proving difficult to overcome.

The answer is not simply to be found in graduating more students from China's colleges and universities. Currently, estimates range that the shortage today and into the future will be somewhere between 200,000 to 300,000 skilled workers that will be needed in this critical sector.

It was also estimated recently that only about 15 to 20 percent of those who graduate with degrees in semiconductors actually go to work in the industry. In 2020, 13.7 percent of the 210,000 graduates chose to work in the industry. There are many reasons for this.

Many graduates don't possess the right sets of skills that are demanded by industry. A large number of the schools have faculty that don't have ample engagement with the industry to understand the real needs of companies.

Many of the textbooks that are deployed are not reflective of the prevailing state of the art, and a large number of institutions don't have pilot research or production lines for training the students appropriately.

Since the big push for educating more graduates in specializing in semiconductor engineering and IC design began, there's been a big curriculum restructuring among many universities.

In 2003, China established IC design and integrated systems as a major. In 2012, it became a special major, but in 2020, it joined the ranks of the so-called first level disciplines.

It became one of the 14 key disciplines that are high priority areas in terms of overall education. These mean that the Chinese government see these as strategic areas for educational development.

Along with the status of IC engineering discipline, 26, and in the future adding two more, 28 colleges were designated to be created as national demonstration microelectronics colleges.

A group of nine were designated in the first tranche and the other 17, 18 will be given money later on down the line. These are the best and brightest in terms of where China's students ought to be going.

This build-out of training capabilities has continued to grow. In October 2020, the NDRC and the Ministry of Education held a joint conference about creating national integrated circuit industry education innovation platforms, again designed to enhance the collaboration between universities and specific companies.

According to a recent article in 191it.com, one key problem continues to be that the industry and the demand for talent is growing so fast that companies cannot wait the four or five-year cycle for the graduates, and this has led now to the development and the establishment of a number of auxiliary institutions that are vocational oriented and that are providing quick training so students can come online in the workforce very rapidly.

While the establishment of these training schools is very important, we still shouldn't lose sight of the role of the universities. They are strategically important to the long-term solution.

One of the problems is the difference in the curriculum between the United States and China. In the U.S., people who are going to work in semiconductors come from a broader array of disciplines, including electrical engineering, chem engineering, mechanical engineering, physics, chemistry, and information engineering. In China, especially with the heightened focus on meeting specific industry needs, there is a greater emphasis on microelectronics as a whole with a little dose of physics.

With some exceptions, depth is emphasized over breadth. As the technologies deployed in this sector become more and more complex, the Chinese approach may prove in the short term to be useful, but may not be pointed in the right direction in terms of the long-term needs.

There is little doubt that China has made a comprehensive commitment to address its talent shortage in terms of the entire value chain of the semiconductor and IC industry. Achieving self-reliance indeed is a strategic national priority.

Will China come up with a grand solution to meet its talent needs for developing an advanced semiconductor industry? China has sought to utilize the same type of solution that South Korea deployed to catch up with Japan in the semiconductor sector.

It has tried to hire retired or part-time engineers from South Korea and Japan, as well as Taiwan to meet the need for experienced talent. This has partially yielded some results, though recently, several Samsung engineers were charged with violating Samsung's IP regulations.

Taiwan has stepped up its efforts to limit PRC firms from poaching Chinese employees from the island's semiconductor industry, and any Americans, as you know, working in China for local Chinese firms have had to leave the country.

Chinese talent recruitment programs also don't seem to offer a comprehensive solution even though there's been an increase in the number of STEM people returning to China.

So, in the final analysis, the burden of solving China's semiconductor challenge falls squarely on the domestic education system. In some respects, we can see ample evidence of progress being made.

Nonetheless, I would conclude it's likely that China's talent dilemma in semiconductors will remain a significant problem for some time in the future. Thank you.

PREPARED STATEMENT OF DENIS SIMON, CLINICAL PROFESSOR OF GLOBAL BUSINESS AND TECHNOLOGY AT THE KENAN-FLAGLER BUSINESS SCHOOL AT UNC CHAPEL HILL

The Training, Education, and Deployment of Semiconductor/IC Talent in China[1]

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"…the journey for professionals in the IC industry is an arduous one, and China hopes promising students can become a key pathway towards significant breakthroughs in the industry."

Zhou Yumei
Former Deputy Director
CAS Institute of Microelectronics
Comments at the March 2021 Two Sessions Meeting

Overview

The global semiconductor industry grew 20% in 2021 with revenues rising to US$590 billion. That type of growth is expected to continue, albeit with a few bumps along the way, to make it a US$ 1 trillion industry. It is anticipated that the demand for semiconductors and integrated circuits will continue to rise as everything from 5G to artificial intelligence to advanced computing to electric and intelligent vehicles will require this technology to advance ahead. It is important to keep this global context in mind because it is against this backdrop that we can best understand China's evolving role today and in the future. In addition, it is important to recognize that as China continues to push ahead in its efforts to develop and advance its own indigenous semiconductor/IC industry, it is working against a moving target. It goes without saying that the key players in the global semiconductor industry are not standing still simply waiting for China to catch up. The leading international companies are engaged in an all-out effort to sustain their competitiveness by adopting AI technologies, improving their manufacturing processes, and hiring the best qualified talent. As a recent 2023 report by Deloitte suggests, the entire face of the semiconductor industry and the global supply chain for semiconductors are undergoing massive changes as a result of onshoring, re-shoring, nearshoring, and friend-shoring—driven by the continued legacy of the COVID pandemic as well as the new geo-political and national security environment.

In fact, it is safe to say that the entire global semiconductor industry basically is faced with the same challenge—namely to recruit and attract as well as develop and retain the qualified talent

[1] The information contained in this document has been drawn from a wide variety of Chinese and English language sources, including Chinese websites, social media, and government reports. The references have been omitted in the draft and will be inserted at a later time.

needed to support the industry in the years ahead. The search for talent, therefore, is a significant issue among all parts of the semiconductor industry. China's situation is particularly difficult because it is playing a catch-up role as it tries to respond to the increasing number of restrictions placed by the US government and its allies regarding PRC access to advanced semiconductor devices and the equipment and software needed to produce increasingly sophisticated semiconductor chips and integrated circuits. Recent events and efforts inside China may suggest, however, that this search for qualified talent is a relatively new phenomenon. Certainly, the intensity of the effort is of recent origin, but the recognition of the critical place of qualified talent at all levels of the industry is something that has roots going back to the onset of the 21st century. As China's S&T leaders as well as top officials in the electronics, telecommunications, and computer industry, (and the defense sector) have realized, building China into an innovation-driven nation will not occur without the effective harnessing of a talent pool able to meet the needs of all industries in the country. The priority given to the semiconductor and IC sectors has made this need for talent even more imperative. Without a sustainable pipeline of high caliber talent, China's goals for the semiconductor sector, especially in terms of further indigenizing the industry, will be not achievable. This leaves talent either as the potential Achilles heel of the industry or its key source of competitive advancement.

Today, China accounts for approximately 35% share of the global semiconductor market, making it the economy with the largest single share of the global semiconductor market—surpassing the US, EU, Japan, and Taiwan. Its efforts to develop more and more elements of the semiconductor value chain are being driven by not only significant internal demand, but also by the clear recognition that with the imposition of new stringent controls by the US on technology transfer, equipment sales, and advanced chip imports, the country's only hope to meet its growing demand for basic and advanced semiconductors must come from domestic sources. With American citizens prevented from working for Chinese entities engaged in the manufacture or research related to advanced semiconductors, the need for qualified, experienced talent has escalated sharply over the last 2-3 years.

Based on data from 2021, it was estimated that the Chinese semiconductor market was valued at approximately US$190 billion. China-based sources only were able to provide US$31.2 million or 16.7% of the demand. Moreover, only 6.6% of that supply came from PRC owned companies versus international firms operating in China. While there are over 30 major semiconductor projects in place, with many due to come online in 2024-2025, it is not likely that many of the new facilities will be working at the cutting edge defined by industry leaders such as Intel. China's stated goal is to reach 70% self-sufficiency by 2025—a goal that looks unlikely to be met given the present limits on China's access to the equipment and software needed to propel the industry forward at such a rapid pace.

To fully grasp the context in which the talent situation is evolving, it is important to consider five major events that have focused on Chinese semiconductor development. 1) In 2014, China

issued its *National IC Promotion Guidelines*. It also established the *National IC Industry Development Investment Fund* (the Big Fund) with approximately US$21 billion in state-backed financing. In 2019, the Fund was renewed with another US$35 billion; 2) In August 2020, the State Council issued policy document *Guofa #8* that laid out important guidelines and tax policies for the development of the industry, including some key recommendations for talent policy (See Appendix). 3) The issuance of the State Council document is aimed at ensuring alignment between key parts of the *14th FYP (2021-2025)* that highlight not only China's broader innovation goals, but also specifically identifies the semiconductor industry as a key target for strong government support and attention; 4) The announcement by SASAC (State-owned Assets Supervision and Administration Commission) in September 2021 that strives to ensure that all SOEs involved in core electronics areas address their shortcomings and operational problems; and 5) The announcement by MoST that the National Key Labs will be expanding their involvement in basic frontier research and key technologies in the semiconductor industry. These five key developments have been complemented by the announced plans of several crucial provincial and municipal governments to put in place initiatives that will carry forward specific projects to support central government priorities for the semiconductor industry. A good example is the Beijing Municipal government, which announced its version of a 14th FYP. In that plan, the Beijing Economic-Technological Area is identified as a base for IC equipment and for building an independent IC industry eco-system. Similar pronouncements were issued by Shanghai, Jiangsu, Zhejiang, and Hubei.

China's Semiconductor/IC Talent Situation

The situation regarding the supply and demand of talent for the PRC's semiconductor and IC sectors is rather complex because of the suddenness with which the pressures for indigenization have increased. With the new regulations imposed on the export of semiconductor technology, equipment and software to China, a range of obvious bottlenecks have emerged, many of which are proving to be extremely difficult to overcome. The situation regarding availability of relevant talent is proving to be one of the most arduous to fix; the answer is not simply to be found in graduating more students from China's colleges and universities, though this is indeed part of the solution to meeting China's growing talent needs. Currently, estimates range from 200-300,000 in terms of the existing and projected shortage of talents to staff the various technical positions in this critical sector. By 2021, it was believed that there were 541,000 persons employed in the semiconductor/IC sector; by the end of 2023, it is estimated that demand will reach 740-760,000 persons. An estimate for 2024 suggests that the demand side will reach 789,000 persons. In 2021, it was estimated there were more than 2800 chip design companies in China; that is a substantial increase over the last 5 years with the big increase occurring from 736 in 2015 to 1362 in 2016 and to 2218 in 2020. In addition, according to SIA in the US, there were nearly 15,000 firms registered as semiconductor enterprises in 2020. Last year, it was calculated that Chinese colleges and universities graduated over 200,000 students who had majored in some facet of semiconductor

engineering. However, only about 15-20% of these graduates actually secured jobs in the industry. (In 2020, only 13.77% of the 210,000 graduates chose to enter the industry.)

There are many reasons for this situation. Many graduates simply do not possess the right sets of skills and experience needed by the industry. As noted, among the 100+ institutions with semiconductor related majors, only 42 actually qualify as "high end" institutions in terms of producing high caliber graduates. Among a large number of schools, the faculty don't have ample engagement with industry to understand the needs of the key companies. Many of the textbooks being used are not reflective of the prevailing state of the art. And, a large number of institutions do not have pilot research equipment or production lines for training students appropriately.

There also has been a major shift in the industry in terms of focus as China as gone from a lower end position in the semiconductor supply chain to greater emphasis on designing and producing its own semiconductors. In 2013, 44% of the companies were focused on testing and packaging, but that number has now decreased to 28%. In contrast, in 2013, 32% of the firms were focused on design but by 2020, that number increased to 43%. Manufacturing has remained relatively stable at 24-29% but the demand for qualified talent is projected to increase as China attempts to manufacture more advanced semiconductors and chips on its own.

It must be remembered in considering the learning environment in many of these institutions that universities are not only educating and training future graduates, but they also are engaged in advanced research related to semiconductors, integrated circuits, etc. As the Chinese say, they are "walking on two legs." However, if the research activities are leaning in the theoretical direction for purposes of academic publication rather than practical application, the results do not contribute much to preparing students for their job assignments post-graduation.

Since the big push for educating more graduates specializing in semiconductor engineering and integrated circuit design began, there has been a massive curriculum restructuring among many universities. In 2003, China established integrated circuit design and integrated systems as a major. It became a special major in 2012. Today it is estimated, as suggested earlier, that over 100 colleges and universities have this major. In 2020, China separated integrated circuit science and engineering from electronic science and technology, and established IC science and engineering as a first level discipline. It became one of the 14 key disciplines classified among "interdisciplinary disciplines" that included IC science and engineering and national security studies (12+2=14). This happened through an announcement by the Academic Degree Committee of the State Council and the Ministry of Education. The first level disciplines reflect the high priority fields designated by the Chinese government; through this designation, universities have an approved framework to set up courses and a whole curriculum, recruit professors, recruit students—all to meet the economic and social development objectives stated by the central leadership. The top ten schools with the highest ranking are: Chengdian

(Chengdu), Xidian (Xian), Peking Univ, Tsinghua Univ, Southeast Univ, Fudan, Shanghai Jiaotong, Nanjing, Zhejiang, Xijiao, and Beijing Post & Telecommunications Univ.

Along with raising the status of the IC science and engineering discipline, 26 colleges and universities were chosen by the Ministry of Education and several other ministerial departments in July 2015 to build national demonstration microelectronics colleges. A group of 9 institutions were selected to be among the first batch of schools to get national level financial support. It was indicated that the remaining 17 would receive funding to move forward at a later time. Two more schools were added (Xiamen University School of Electronic Science and Technology (September 2018) and the Shenzhen-HK School of Microelectronics at the South China University of Science and Technology (February 2-19). Taken together, these 28 schools represent the strongest, highest caliber schools of microelectronics—including semiconductors and integrated circuits—in China (see Appendix).

These demonstration microelectronics colleges were complemented by the establishment of 20 national integrated circuit talent training bases. The roots of these training bases goes back to 2003 when the Ministry of Education first approved the construction of so-called "national IC training bases" at seven universities (later expanded): Peking Univ, Tsinghua, Zhejiang, Fudan, Xian Univ of Electronic Science and Technology, Shanghai Jiaotong, Southeast Univ, Univ of Electronic Science and Technology, and Huazhong Univ of Science and Technology in Wuhan. In August 2004, the Ministry of Education approved six more institutions: Beijing Univ of Aeronautics and Astronautics, Xian Jiaotong, Harbin University of Technology, Tongji Univ, South China Univ of Technology, and Northwest University of Technology. In June 2009, five more universities were approved by the Ministry of Education, including Beijing Univ of Technology, Dalian Univ of Technology, Tianjin Univ, Sun Yat-sen Univ, and Fuzhou Univ. Among these twenty institutions, two are located in the northeast, three are in the northwest, two are located in the south, five are in Beijing/Tianjin, and the remainder are located the Yangtze River Delta.

This buildout of training capabilities has continued to grow. In October 2020, the NDRC and the Ministry of Education held a joint conference about the development of "national integrated circuit industry-education integrated innovation platforms." This initiative is part of the Double First Class project under the Ministry of Education in which the government has designated not only individual universities for special support to become world class, but also specific disciplines within a broader range of universities that may not be qualified as whole for world class status but have selected disciplines that are top notch. Eight universities were identified as active players in the first round: Peking, Tsinghua, Fudan, Xiamen, Nanjing, Huazhong, Univ of Electronic Science and Technology, and Xian University of Electronic Science and Technology. Four of the platforms were under construction and four had feasibility studies under review as of late 2020. The key element of these platforms (as their name suggests) is to enhance the cooperation between universities and specific companies. The level of support ranges from 470 million yuan for Fudan to 200 million yuan for Xiamen University. Each one has a specialized

mandate, e.g. Tsinghua is focused on CMOS logic devices and circuits, memory, and sensors. Data regarding the second batch of four schools has emerged with Huazhong in Wuhan getting about 341 million yuan and Xidian in Xian receiving 354 million yuan. According to the Tencent News report, Chengdian and Xidian are the most attractive for potential applicants because they remain in the "A+" category even though they require lower gaokao scores for entrance.

According to a recent article from 191it.com, the China Integrated Circuit Industry and Talent Development Report (2020-21), in 2020, indicated there were approximately 210,000 IC-related graduates; currently, it is expected in 2023 actual demand will reach 76,500. Given the small percentage of how many students chose to enter the industry and the small percentage who meet the requirements of the hiring firms, the report suggests the most current estimate of the overall shortfall (multiyear) will be over 200,000. The problem is that the industry is growing so fast that companies cannot wait for the 4-5 year cycle for students to graduate; in 2021, 106,000 new IC chip-related enterprises were registered, a 33.5% increase from the previous year. This has created the impetus for the emergence of an additional component in the overall training system; a new group of auxiliary training organizations has emerged to cut the time for preparing students for jobs in the semiconductor and IC industry. Since 2020, their numbers have been growing rapidly. The main specializations include chip verification and chip design—initially at a 2:1 ratio. These training firms provide a very intense education to qualified applicants; most applicants have some background in the subject matter to allow them to get a quick jump start. In general, the primary goal of the applicants is to land a job in a big chip firm with lots of upside potential. Competition for jobs is extremely intense; these days many of the applicants are willing to forgo higher salaries in new startup firms for more stable employment in established companies.

With the problem of demand exceeding supply in terms of qualified graduates from universities and training schools, the salaries in the IC sector have started to increase. According to the White Paper on Talent in the IC Industry (2020-21), the average salary in the semiconductor industry increased by 4.75% in 2020 and the growth rate in the IC industry was 8.0%. Estimates are that it reached 9.0% in 2021. Tuition at the training schools is between 20,000-30,000 yuan for a multi-month course. There is a great deal of skepticism among potential applicants as to whether these schools can really secure for them a well-paying job. On the other hand, according to multiple reports, the graduates from the training program often don't meet the expectations of the companies. The key problem in this regard is finding competent teachers who have the type of knowledge and experience required by potential employers. With the number of teachers also in short supply, their salary demands also have increased. All in all, this has created a rather chaotic situation with lots of poaching of employees, poaching of teachers, and even poaching by schools of potential applicants. Perhaps this quote from a co-founder of the IC Xiuzhen Academy captures the situation best:

> *"We are short of people now, and many companies will "dig" each other if they cannot supply talent in the short term. A person*

is in this company today and goes to that company tomorrow. Their salary has tripled as they have changed three companies. This is actually. a great waste of resources. The money has been lost and it has not created much value for the company."

In terms of overall employment, based on the 2021 report on semiconductor talent issued by 51job, a talent search firm, the volume of employees recruited from the market was 236,000 versus 67,000 that were recruited from campuses. Private enterprises in China recruit primarily from the market; private enterprises accounted for 81.3% of the recruitment efforts and provided 79.6% of the jobs from the market. Campus recruitment for private enterprises occurred in only 53.5% of the cases. SOEs recruit primarily from campuses. In 2021, however, they accounted for only 7.2% of the employers, but provided 35% of the jobs for graduates.

The situation regarding talent training and employment mirrors some of the overall problems in the semiconductor industry as it has sought to ramp up in response to US restrictions. In October 2020, the NDRC got involved in addressing what it called "the chaotic situation" facing the industry. The NDRC specifically noted that while "the enthusiasm for domestic investment in the IC industry is constantly rising," too many companies "with insufficient knowledge of IC development have blindly entered into projects." This affects the employment situation as unqualified companies are trying to attract talent without much prospect of business success. The candidates end up in unproductive situations and many leave the sector because they are simply uncomfortable with the uncertainties and problems.

China's University Sector

While the establishment of an array of training schools specializing in semiconductor-related training is valuable, the important role of Chinese universities should not be underestimated. In recent years, China's Ministry of Education, with advice and counsel from the PRC leadership, has put in place a variety of reforms and policy changes to help strengthen the quality of both education and research in both national level and local level higher learning institutions. These efforts have resulted in dramatic improvements in the academic and administrative operations of a large number of institutions. One of the outcomes is that an increasing number of PRC universities are now listed among the top universities in the world.

Of the top 1499 universities ranked in the world, the US has 255 institutions on the list accounting for 17% of the total, while China has 176 institutions on the list, accounting for almost 12%--putting China in the number two spot ahead of the UK, Canada, Germany and France. In the QS 2022 rankings of higher education institutions, Tsinghua was ranked 17th, Beijing University was ranked 18th, and Fudan University was ranked 31st—not a bad result for a country whose higher education system was basically decimated as a result of the turbulence of the Cultural Revolution (1966-1976).

Given these newest rankings and considering the tremendous progress that has been made especially in China's top tier institutions, it should not be surprising to find that universities such

as Tsinghua and Beijing University have been asked to play a strategic role in supplying qualified talent. Before engaging in a discussions of the various new initiatives underway, it is important to remember that the ability to create long term competitive advantage in semiconductors derives from three main sources: First, and most obvious, is the ability to master the technological improvements that are occurring across the industry at home and abroad; second, and no less important, is to develop a talent pipeline that can provide the intellectual creativity and ingenuity to push the frontiers of knowledge; and third, is the ability to understand and leverage knowledge and understanding of the economics of the industry and associated managerial requirements at the factory and R&D levels. This last area is often given little, if any, attention, especially in terms of education and training in China. To the best of my understanding, for example, despite the huge growth of MBA education in China, there are few, if any, specialized degree programs in China for preparing future managers and analysts who are trained to understand the specifics of semiconductor business cycles, pricing dynamics, and related issues.

When Intel first opened up its massive 65-nanometer semiconductor facility in Dalian in 2007, it held discussions with the Dalian University of Technology about launching a program to train semiconductor engineering talent for the city, but when it tried to develop interest in a program in the management school about economics and management in the semiconductor industry, there was little to no receptivity. This is not a small problem because taken more broadly it is linked to the dearth of qualified senior managers who have an in-depth understanding of the dynamics of the industry domestically and on a global scale.

Returning to the on-going semiconductor-related initiatives occurring at China's major universities, several seem worthy of attention because of their rapid progress. The configuration of the curriculum and pedagogical approach for educating future semiconductor engineers reflects a key difference with US counterparts. Those being groomed for careers in semiconductors in the US come from a broader array of disciplines, including electrical engineering, chemical engineering, mechanical engineering, physics, chemistry, and information engineering. In China, especially with the heightened focus on meeting specific industry needs, there is greater emphasis on microelectronics as a whole with a dose of physics involved. With some recent exceptions, depth is emphasized over breadth. As the technologies being deployed get more and more complex and the need for a broader perspective becomes more essential to drive new technological advances, the PRC education approach, while yielding short term benefits, may not be pointed in the right direction to solve the bigger problems that lie around the corner.

Another issue is the mix of undergraduate (UG), masters, and PhD students. According to one source, as the semiconductor industry becomes more and more research intensive, and comes to depend more on new knowledge breakthroughs, China's emphasis on UG students also may turn out to be productive in the short term but inadequate to keep China competitive in the future. At present, 80% of the graduates securing jobs have UG degrees, 15%-18% have masters degrees, and less than 5% hold doctoral degrees. This mix will have to change over time so that the R&D side of the equation can be given more support.

One of the most strategic developments associated with the big push on enhancing semiconductor education involves strengthening the ties between industry and universities. In May 2021, the Talent Exchange Center of MIIT and the Industry-Education Integration Research Association of the China Higher Education Society jointly hosted a major conference in Chongqing that included a keynote speech by Li Ning, a director of the MIIT Talent Research Center. The speech emphasized three key points: a) universities need to do a better job of working with companies so that graduates are better positioned to address the problems and issues actually occurring within the companies; b) do a better job of translating research results into solutions applicable to the needs of the IC enterprises; and c) develop effective curriculum that necessarily involves a greater voice from industry so that universities can adjust and adapt their curriculum in the right directions. This call for improved connectivity reverberated across the entire education community and semiconductor/IC industry and has reset the tone for enhancing collaboration in multiple areas.

Five Case Examples

1.Shanghai has become a leader in supporting the central government's big push to meet the semiconductor industry's talent needs today and in the future. It has now set up three campuses in the city to focus on developing talent for the chip industry. One campus is in Jiading district, one in Zhangjiang district, and one in Lingang district. These three campuses are part of the municipal government's plan to make Shanghai into a leading base for the semiconductor industry. In January 2022, an ambitious training program was announced to produce talent to meet the need for qualified employees across the entire semiconductor supply chain. The Lingang project involves Shanghai University and the city's Integrated Circuit Industry Association.

2. Beijing, led by both Tsinghua University and Beijing University, has responded in a comprehensive fashion to the central government's admonishments. In April 2021, Tsinghua formally established a School of Integrated Circuits, which is aimed at development of a world class curriculum for semiconductor education. Their plan is to invite established experts to teach some classes and provide some lectures to establish a strong connection with industry. Tsinghua has been involved in teaching about semiconductors since 1956! Over the last several decades, it has sent 4,000 UG students, 3,000 masters students, and 500 doctoral students to work in the field of integrated circuits. The creation of the school has been accompanied by lots of political fanfare linked to China's push for greater technological self-reliance. Peking University is known as the originator of microelectronics in China. It too has established a School of Integrated Circuits. According to press reports, the unique aspect of the school at Peking University is its multidisciplinary orientation; the curriculum will strengthen the integration of computer science, mathematics, physics, chemistry, material science, and other related fields. Like in most other instances, the launch of the IC school at Peking University was accompanied by lots of fanfare related to serving the national interest as well as making technological breakthroughs.

3. Another interesting example from Beijing involves the case of Beihang University, which is one of the seven sister universities under the MIIT. In 2020, Beihang changed the official name of its microelectronics school to the "School of Integrated Circuit Science and Engineering." Beihang has been involved in a high priority project called "the Excellent Engineer Training Summit Forum," which was held in September 2022. The forum involved the Ministry of Education and SASAC as key organizers. The summit builds on the "spirit" of the Central Talent Work Conference held in 2021 and was focused on strategies in the education and training of engineers as well as ways to promote more in-depth cooperation between universities, enterprises, and research institutes. Other key players in the forum were Tsinghua University, Zhejiang University, Huawei, China Electronic Technology Group, China Aviation Industry Group, and Zhongguancun laboratory. Along with discussions and presentations regarding general engineering, there were at least two important sub-forum on integrated circuits and engineering training. The meeting also provided an opportunity for the China Semiconductor Industry Association and the Ministry of Education to introduce the "Core Star Plan." Developed in April 2022, the plan focuses on key improvements in two areas of education for integrated circuits: 1) improving the skills of college graduates in IC engineering; and 2) enhancing the pre-job training of future employees, which would include developing better internship linkages. The ultimate goal of the entire program is to put in place an "excellent engineer training system" with Chinese characteristics that is of world class quality.

4. In Shenzhen, in June 2021, the Shenzhen Technological University also launched a new school focused on integrated circuits named "the College of New Materials and New Energies." The founding of the school was accomplished in conjunction with the signing of a memorandum of strategic cooperation with the Chinese company SMIC. School officials have indicated their intention to forge close ties with other Chinese firms including Huawei and BYD. Connecting with industry will be a key part of the school's overall strategic positioning.

5. Finally, a different approach to addressing the need for talent in the semiconductor/IC sector is highlighted by the example of Nanjing Integrated Circuit University in Jiangsu province. It falls neither under the jurisdiction of the Ministry of Education or the local provincial government. Instead, it is under the oversight of the Jiangbei New Area Management Committee. Its principal purpose is to work with local industry to solve existing or emerging problems. Founded in October 2020, it will not award degrees; it will provide certificates and its faculty will be drawn from among senior engineers working in local industry. It will not have a traditional faculty.

Final Thoughts

> *"…semiconductors [are] as important for manufacturing as hearts for humans. When your heart isn't strong, no matter how big you are, you're not really strong,"*
>
> Xi Jinping
> April 2018, Visit to YMTC
> (From NYTimes August 29, 2022)

There is little doubt that China has made a comprehensive commitment to developing an array of viable solutions to address its talent shortage across the entire value chain of the semiconductor and IC industry. Over the last 2-3 years in particular, the PRC leadership has not missed a chance to create new momentum and provide substantial financial resources (and incentives) to address the talent needs of this strategically important industry. Achieving greater self-reliance in all aspects of the semiconductor industry is not simply desirable under current circumstances; it has become a top national priority. The Ministry of Education, the MIIT, the NDRC, SASAC, and the MoST all have strengthened their collaboration to enhance the chances for success moving forward. As suggested earlier, however, the difficulty of enhancing China's overall competitive position in semiconductors and ICs is compounded by the fact that the technology and expertise required for success continues to evolve and change at an accelerated pace. The challenge is to see whether China can combine the power of its universities, think tanks like the Chinese Academy of Sciences, National Key Labs, and enterprises to identify breakthrough opportunities.

That said, there still are some very practical problems that must be overcome. It has become clear from the Chinese own assessments of the evolving situation that not every job in this sector requires applicants with advanced degrees. Vocational schools, community colleges, and even the types of specialized schools noted earlier can help to provide solutions to the demand for talent. However, there also is evidence that there are some basic problems that must be addressed, including replacing outdated textbooks, identifying new faculty who are better connected to industry, legal protections so that companies that share their know-how are not putting their IP at risk, increasing the availability of experimental equipment inside schools at all levels, and stabilizing the labor markets so that talent mobility is an asset rather than a liability as it is under the current fluid situation.

Will China come up with a grand solution to meet its talent needs for developing an advanced semiconductor/IC industry? China has sought to utilize the same type of solution that South Korea employed to catch up with Japan in the semiconductor industry; it has tried to hire retired or part-time engineers from South Korea and Japan as well as Taiwan to meet the need for experienced talent. This has partially yielded some positive results, though most recently several former Samsung personnel were charged with violating the company's IP regulations. Taiwan has stepped up its efforts to limit PRC firms from poaching employees from the island's semiconductor and IC firms; there already are a large number of engineers from Taiwan working for mainland companies. This number is being reduced daily. And, any Americans working in China for local Chinese firms have had a leave as noted previously, China's talent recruitment programs also don't seem to offer a comprehensive solution, even though there has been an increase in the number of STEM professionals returning to China over the last 2+ years; the best and the brightest among Chinese-American scientists and engineers still chose to remain in the US in their current jobs.

So, in the final analysis, the burden of solving China's semiconductor talent challenge falls squarely on the domestic education system. In some respects, we can see ample evidence that

progress is being made. The five examples cited above highlight how thinking about curriculum and university-industry connectivity have changed for the better. Nonetheless, given the speed of technological advance and the growing need for import substitution to become effective, it is likely that China's talent dilemma in semiconductors and ICs will remain a significant problem for some time into the future. There are many moving pieces involved in achieving the level of self-reliance in semiconductors and IC technology that is needed to remain competitive on a global level. While it is never a good idea to write off China's potential for catching up, there promise to be a plethora of hurdles still out there over the next few years—with the shortage of qualified talent being one of the most serious and consequential.

Appendix

Talent Provisions of the August 2020 State Council Guofa #8

"Several Policies to Promote the High-Quality Development of the Integrated Circuits Industry and the Software Industry in the New Era"

V. Talent Policy

(22) Further strengthen the construction of integrated circuits and software majors in colleges and universities, accelerate the establishment of first-class disciplines for integrated circuits, closely adjust the curriculum, teaching plans and teaching methods in time in line with the needs of industrial development, and strive to cultivate compound and practical high-level talents. Strengthen the construction of integrated circuit and software teachers, teaching laboratories and internship training bases. The Ministry of Education, together with relevant departments, strengthens supervision and guidance.

(23) Encourage qualified universities to adopt cooperation with integrated circuit enterprises to accelerate the construction of demonstration microelectronics colleges. Priority should be given to building and cultivating integrated industry-education enterprises in the field of integrated circuits. For pilot enterprises included in the construction and cultivation of integrated industries and education enterprises, if the investment in the establishment of vocational education meets the regulations, the education surcharge and local education surcharge payable by the enterprise in the current year may be deducted in proportion to 30% of the investment amount. Encourage social-related industry investment funds to increase investment and support college joint ventures to carry out the construction of a special resource pool for the training of integrated circuit talents. Support the School of Demonstrative Microelectronics and the School of Characteristic Demonstration Software to cooperate with internationally renowned universities and multinational companies to introduce foreign teachers and high-quality resources, and jointly train integrated circuits and software talents.

(24) Encourage local governments to commend and reward high-end talents who have made outstanding contributions in the field of integrated circuits and software, as well as high-level engineers and R&D designers, in accordance with relevant regulations of the State, and improve the equity incentive mechanism. Through relevant talent projects, we will strengthen efforts to introduce top experts and outstanding talents and teams. Give priority to exploring relevant policies to introduce integrated circuit and software talents in industrial agglomeration areas or related industrial clusters. Formulate and implement the annual plan for the introduction and training of integrated circuit and software talents, promote the construction of the national integrated circuit and software talent international training base, and focus on strengthening the medium- and long-term training of urgently needed professionals.

(25) Strengthen industry self-discipline, guide the rational and orderly flow of integrated circuit and software talents, and avoid vicious competition.

28 Top Microelectronics Academic Institutions

Number	Name	Number	Name
1	Beijing University	15	Tongji University
2	Tsinghua University	16	Nanjing University
3	Univ of Chinese Academy of Sciences	17	China Univ of S&T in Hefei
4	Fudan University	18	Harbin Inst of Tech
5	Xian Elec S&T Univ	19	Fuzhou University
6	Shanghai Jiaotong	20	Shandong University
7	Southeast University	21	Huazhong S&T Univ
8	Zhejiang University	22	National Defense S&T University
9	Electronics S&T Univ	23	Huanan Polytechnic
10	BUAA	24	Zhongshan Univ
11	Beijing Inst of Tech	25	Xian Jiaotong Univ
12	Beijing Univ of Technology	26	Northwest Polytechnic Univ
13	Tianjin University	27	Xiamen University
14	Dalian Univ of Tech	28	South China Univ of Technology
Source: Ministry of Education			

Ranking of the 42 Top Universities in Electronics Science and Technology

University	Rating	University	Rating
Electronics S&T Univ	A+	Harbin Inst of Tech	B
Xian Electronics S&T	A+	Xiamen Univ	B
Beijing Univ	A	Wuhan Univ	B
Tsinghua Univ	A	Zhongshan Univ	B
Southeast Univ	A	Southeast Polytech	B
Fudan Univ	A-	East China Normal	B
Shanghai Jiaotong	A-	China S&T University	B
Nanjing Univ	A-	Nankai Univ	B
Zhejiang Univ	A-	Beijing Univ of Tech	B
Xian Jiaotong Univ	A-	Nanjing Polytechnic	B
Beijing Posts & Telec	A-	Shandong Univ	B-
BUAA	B+	Hunan Univ	B-
Beijing Inst of Tech	B+	Chongqing Univ	B-
Tianjin Univ	B+	Dalian Univ of Tech	B-
Jilin Univ	B+	Xinan Jiaotong Univ	B-
Defense S&T Univ	B+	Beijing Jiaotong Univ	B-
Huazhong S&T Univ	B+	Hefei Univ of Tech	B-
Northwest Polytechnic Univ	B+	Anhui University	B-
Nanjing Posts & Telec	B+	Fuzhou Univ	B-
Air Force Engineering University of PLA	B+	Army Engineering University of PLA	B-
Hangzhou Electronics S&T University	B+	Xian Polytechnic Univ	B-

COMMISSIONER PRICE: Thank you. So, now I'm going to turn to the Commissioners. We'll do this in reverse order alphabetically again, so Vice Chairman Wong?

VICE CHAIRMAN WONG: Thank you. Ms. Peterson, you know, a lot of your testimony, and I should read it more closely, is focused on the proliferation of the AI major or areas of study that are focused on AI.

But as you say, I mean, AI is a cross-disciplinary subject pulling from not just CS, but I assume statistics, data science, cognitive science, both engineering and theoretical disciplines.

So, and maybe I'm unaware of this, but we don't see a similar proliferation of AI-specific majors or courses of study in the United States, at least not to the same extent as in China.

But do we still have an advantage though simply because of the strength of the education, particularly the higher education system that we have, in those individual disciplines that make up the AI, you know, discipline, so strong CS as you mentioned, but strong, I don't know, ethics and philosophy, strong cognitive science, strong, you know, this whole area of brain study that can be applied to the AI sphere?

Basically, I'm saying in comparing us to China, are we still at an advantage? Because it's just we don't have the same push, at least I don't think, to make AI a major. It's kind of strange from our western perspective to make that a discipline of study. Anyway, it's kind of a general question, but over to you.

MS. PETERSON: No, that is an excellent question and I will say first that there is no one agreed upon definition for AI education.

China has taken a stab at standardizing that and that is just generally the approach that the Ministry of Education takes to majors is to standardize them.

So, for the AI major itself, it's standardized under the engineering category, but that being said, both in the U.S. and China, especially in China before the launch of the AI major, it was pretty similar in both countries in which computer science departments were the main breeding ground for AI talent.

And so, some of these computer science majors in both countries have an AI concentration or elective courses that can train you up, but in China, they've taken that a step further with not just the AI major which has the computer science core classes, has the math and statistics, but they go beyond that to introduce, you know, natural language processing and computer vision, and to really get you into the machine learning and the deep learning techniques which are a bit more of an optional direction in the U.S. computer science.

I will note that there are certain programs in the U.S. There's no comprehensive tally that we know of that really quantifies how many AI majors there are, but I will point to Carnegie Mellon has a Bachelor of Science in Artificial Intelligence where the curriculum design actually looks quite similar to what I've seen for the Chinese approach where they are giving you the introductory methods and the hands-on tools that you need to learn how to design and deploy AI systems.

So, I would say that while the U.S., we are not intending at all for the U.S. to replicate the Chinese approach. It was mentioned in earlier panels the decentralized approach is very much a strength of the U.S. system and it allows for more of that organic development, and the discussion and integration of ethics to the degree.

That's why my recommendations really hone in on starting that interest early. China has clearly had some success in starting their AI education so early and allowing students to realize that it is a possibility to work on those topics.

So, to the extent that you can integrate that early on in the U.S. education system will help more people concentrate in computer science with a focus in AI or AI majors entirely.

VICE CHAIRMAN WONG: So, China's efforts to create and standardize the education system and also set up, or the higher education system in these majors and also to set up research institutes and public-private partnerships, is this more focused on what you would term and what gets more media attention on general AI, or is it narrow AI, or does the distinction not really matter when you're talking about this level of research and education?

MS. PETERSON: Right, so I have noticed that they are doing both. So, there are a lot of ones that's like, you know, ocean science in AI, and so those are more like application types.

There's ones that actually do focus quite a lot on ethics, but then there are also ones that are shifting into more of the future applications of AI, so more of like brain interfaces and things like that, like Wuhan University is a good example of that.

So, I would say that they are focusing on more applications that are being used currently, but they are also in the more forward leaning ones that we should be paying more attention to as those are on the true leading edge.

VICE CHAIRMAN WONG: Thank you.

COMMISSIONER PRICE: Commissioner Wessel?

COMMISSIONER WESSEL: Thank you. Thank you to both of our witnesses. I want to pursue in a way what Commissioner Wong was going after and understand the quality of the education as well as, and I think you said depth versus breadth, that with things like self-healing chips, you know, architecture on the core versus the edge, all of the various things you know I'm sure a lot better than I and similarly in AI.

Are the sanctions that the U.S. has imposed and limitations relating to EUV and, you know, enabling technologies, production technologies, what kind of effect is that having and do you think that the workarounds, if they can be developed, might create new technologies that, you know, we will be behind in? Mr. Simon, do you want to start?

DR. SIMON: So, my sense is that while at the production level, the impact of our policies has already been felt, in the research level, I think that it hasn't had much impact.

And the reason why is that this is part of international science and technology collaboration. The Chinese have as much access as we do to all of the international journals and publications that are out there.

They're also a part of all of the international scientific and technical bodies that deal with any kind of related issues. So, there's no dearth of information flowing in and also by the way, out of China.

And I know there's a lot of work that's been done that's looked at the public, top-tier publications in science and engineering that have involved co-authorship by Chinese and American authors.

And increasingly, those are not what we might call ethnic partnerships, you know, a Chinese-American with a Chinese on the mainland. These involve a more widespread spectrum of Americans and also some different kinds of universities.

So, I don't think the problem is on the research side right now as much, though again, it will be important to see if some of the latest developments in different kinds of chips, and materials, and all does make its way into companies like SMIC, et cetera.

The fact that they are paying such close attention to these industry-university partnership and they're fostering an environment to facilitate collaboration suggests that they recognize the problem and that they are, you know, onto it. It will take a while to get them to work, but as I cited in my larger paper, there's just numerous examples of these.

The second point is that at the best universities, that's where the best progress is being made, and you have to understand, you heard this morning a little bit, there's a real bifurcation of the Chinese higher education system.

Somebody used 100 universities. I think that's a little bit too much. I think after you go beyond the first 25, 30, at least on the civilian universities, the drop-off is very, very sharp.

You can go to 100 of the top American universities in whatever field and get a pretty good education, a world-class education, but in China, I think the drop-off is sharp and it reveals itself in first the faculty, the quality of the faculty, and second, the learning and instructional facilities that are available to the students.

COMMISSIONER WESSEL: Ms. Peterson?

VICE CHAIRMAN WONG: Yes, so I very much agree with what Dr. Simon said about the drop-off in quality in universities and that is why I highlighted that even if it sounds quite shocking that there's 440 universities and in 2022 alone, 95 universities that added that, with the exception of Beijing University, it's quite low-tier universities that I had never heard of, and so there is very much the question of if they are just jumping on the bandwagon.

They don't have the instructional resources or the quality of faculty to really teach the concepts that are needed, and also on the employer side, on the demand side, they may not find the quality of the education sufficient to employ that future talent.

Even if there are these talent shortages, they may not bite on that talent, and there's a lot of anecdotal reports coming out on just the widespread issues that are being faced across China across all of the tech sectors in terms of difficulty for talent to find employment.

On the export controls question, I think one thing that hasn't really been looked at that I think deserves more attention is how is this going to change the calculations of semiconductor talent, now that they have been severely restricted, if they are going to then choose to leave the country?

And so, that they would still be able to, in theory, access that knowhow once they leave China's borders, but that is something that I think would create a massive brain drain and exacerbate the semiconductor talent shortage even further domestically in China.

COMMISSIONER WESSEL: Thank you.

COMMISSIONER PRICE: Commissioner Schriver?

COMMISSIONER SCHRIVER: Thank you, Madam Chair. I just thank the witnesses for your statement and contributing your expertise. No questions from me at this time.

COMMISSIONER PRICE: And I'm going to pass and save mine until the end, so Commissioner Helberg?

COMMISSIONER HELBERG: Thank you, Ms. Peterson and Dr. Simon. Ms. Peterson, my first question is for you, and I have a number of questions that I'll submit for the record, but my first one is one of your recommendations was to incorporate hiring criteria and AI skills at OPM.

And a challenge with that is that in the U.S. tech industries specifically, talented AI researchers and engineers are very rarely professors at universities, let alone in the government, because they're offered millions of dollars a year to work at private companies. So, it's very hard for the government or even the academic sector to compete with the private sector for high-end engineering talent.

You listed an example of the voice recognition iFlytek company that partnered with public colleges to launch several AI colleges across China. Can you give us a bit more color on what that partnership looked like and the mechanisms of how it worked?

MS. PETERSON: Sure, so to answer your second question first, so there's a number of tech companies that have created AI colleges, and so this is something that both predated the 2018 plan that I referred to that said that we need at least 50 of these research institutes and colleges before 2020.

So, these, I see the companies working most in the research institute side of things. So, they are really driving -- they are taking the application scenarios that they are aware of as the most challenging things that they see in industry and they're directly bringing those problems into the classroom. They are helping to design curricula with that in mind.

And then they are also letting instructors and students alike, so these students can be undergraduates. They are usually more on the graduate side is what I've seen, and so they are able to both --

Instructors are able to kind of work at companies like iFlytek and get that knowhow, and then there's this virtuous cycle where they then bring it back into the classroom, and the same thing with students. Students can go do training at these companies and bring that knowhow back into the classroom.

And then I haven't seen necessarily formalized pathways for those students to then go work at places like iFlytek in the future, but I would not be surprised if some of that talent then went to go work for them full time, but this is something that's very much -- it's not necessarily -- there's the rural-urban divide that plays into this.

So, while there are major tech companies that are bringing AI-enabled education platforms to assist students' learning into rural areas, that's not the same thing as people who are working at those companies directly coming to your classroom and teaching you about the industry, the like cutting-edge research findings and the industry findings.

So, there, I see another divide in terms of the quality of education that people in more rural areas perhaps cannot get because they don't have access to those real-world industry partnerships.

COMMISSIONER HELBERG: Thank you so much, and before I run out of time, a question that I'd like to level for both of you is what insight about China's efforts on AI or about how it uses education to promote its industries do you believe to be true that most people might disagree with you?

DR. SIMON: Can you repeat the last part of your question?

COMMISSIONER HELBERG: Sure, what insight about China's efforts on AI or about how it uses education to promote its industries do you believe to be true that most people might disagree with you?

I guess so much has been written about China artificial intelligence and semiconductors. I'm curious to know if there are facts or truths that you believe to be true that a lot of other people might disagree with you on that are different, that depart from the mainstream of what other people have already covered?

DR. SIMON: Okay, so from my understanding and what I see in semiconductor, to prepare for this testimony, I went and looked at what is going on state-of-the-art with respect to American semiconductor companies, et cetera.

And I think that the use of AI machine learning tools, data science, all of that are now heavily embedded in the mainstream of our industry. And as I read this, I kind of started to look for do I see a lot of examples of this happening in China?

I think China is at a very embryonic level in making this happen, but I think in the education system, there is strong recognition that these tools are going to have to be brought into the mainstream of education in order to make sure that the graduates are able to meet the needs of Chinese industry in the years ahead.

I think the one thing that we all have to remember which is really critical, science popularization in China is something that's very important.

And so, because something is happening in AI or what other advanced science area, the reality is that the Chinese government does see educating the general population in science as something to be important for the long-term development of the civilization.

I think that's something we shouldn't lose sight of, that thinking in a modern way, you know, getting people out of the -- particularly in the rural areas where there were a lot of taboos, and superstitions, and things of that sort, getting them into the modern world of the 21st century is something that the government and the Ministry of Education in particular recognizes as very important to China's long-term development.

So, not everyone who is growing up in a rural area is going to become an AI specialist, but as a citizen, they need to understand what AI means to their lives and how it's going to be utilized.

Whether China is doing that in the best way possible, I can't confirm that, but what I can say, that it is happening, and it's happened like that when the Chinese encountered the information technology revolution. As they came out of the cultural revolution, they were already ten years behind, so they had a lot of catching up.

So, I think that this mass education effort is something we shouldn't discount in helping to further education the population, probably not to the level that we would think adequate, but nonetheless for China, it is working and it is having an impact I would say.

COMMISSIONER PRICE: Thank you. Commissioner Friedberg?

COMMISSIONER FRIEDBERG: I want to actually follow that point, but let me ask the question in this way. I wonder how should we think about the requirements of a certain right-sized AI, national AI education program?

Because, Ms. Peterson, what you've described is really a massive across-the-board effort from all levels in China, primary school, high school curriculum, AI majors.

You know, a skeptic might say this is what happens in a centralized system when the word has gone out that AI is a big and important thing, and everybody at every level wants to attach that label to whatever they're doing in part in order to get funds from the central government.

But you do wonder how many of those people coming out of all of these programs are actually going to be capable of doing the kind of work that needs to be done to implement and to make AI systems useful?

And I wonder if this might not turn out to be in some way similar perhaps to computers, where you had a relatively small number of people who design, and them some larger number of people who build them, a larger still number of people have to be trained to operate and maintain

these systems, and then a vast population of people who use them, but don't necessarily understand them and don't necessarily have to be educated to a high level in order to use them effectively.

So, I guess I'll pose that to Ms. Peterson. What would a right-sized AI education program, for example, in this country look like?

MS. PETERSON: So, that's an excellent question. I very much share your sentiments, and I highlighted similar risks that they may run into challenges with shoddy implementation beyond the most elite universities.

So, I would cite a more recent example as well with like the whole ChatGPT fever, that you have all of these companies that are trying to pour in and develop similar like copycats to ChatGPT even though they don't have any background in that field, that subfield of AI whatsoever, and I think like Meituan is a good example of that, the food delivery giant.

But to more explicitly answer your question, I think there already are good programs in the U.S., so at the high school level as well. I think like one example that I would want to point you to is Gwinnett County in Georgia.

They have this interdisciplinary approach to AI that introduces some of the technical concepts as well and gets students interested in knowing, this is similar to what Dr. Simon said, to know how AI is affecting your life, but also get a little bit more of that rudimentary introductory technical understanding to know, to be able to develop that interest and potentially shape you working on those topics in the undergraduate level and beyond.

So, I would say at the elementary school level, really introducing like this is how AI is affecting your life.

This is something similar to initiatives that have already been done for a long time from the NSA, for example, trying to do outreach to help students understand like this is what cybersecurity is and this is why cybersecurity is important.

This is how you can get involved and the different roles you can do, so similar initiatives for that both on the technical and the non-technical side.

At CSET, we emphasize that the AI workforce is not just the most technically trained individuals. It is also those who are, you know, product managers and work on the commercial side, and the legal side.

And so, everyone having a better understanding of how AI affects your life and then there are certain individuals within that who have the most advanced technical training, I think that would produce the most robust AI talent pipeline in the U.S.

COMMISSIONER FRIEDBERG: Thank you. Both of you make reference to figures that suggest that at least as of, I think 2019 was the last number, a very high percentage of top graduates in relevant fields from China who are studying in the United States are staying in the United States for at least five years or longer.

Do you have any sense of what's happened more recently since COVID, and then more broadly, and maybe this is something to deal with in the record, what kinds of policies might the U.S. to pursue in order to encourage people to stay? So, just a quick question about the current data and I'd maybe ask Dr. Simon.

DR. SIMON: Although the last number that I heard actually the other day was 1,400, and that is the number of scholars, postdocs, et cetera that over the last two years have decided to go back even though they had positions here in the United States. That's not a big number, but it's not a small number either.

I think the big question right now is that many of these people literally are wrestling with whether they should stay, return to China, or go to a third country.

And I have a number of examples of Chinese friends here in the United States who have been here, some for 20 years, who are now talking about going to places like Saudi Arabia and Kuwait to these new universities that have been built there because they can do their research and work, and they also can continue to collaborate with Americans and Chinese without running into political problems like they would if they stayed in one or the other country.

So, I think that we have to be cognizant that recent events, what happened, the violence in places like Michigan State, some of the experiences of felt racism, the suspicions under which they were under The China Initiative, et cetera, have really cast a dark cloud over the professional lives of many people.

I think we underestimate the degree to which that has had a negative impact for these people and they are, they're very, very cautious right now. In fact, even if we wanted to promote more Sino-U.S. cooperation in research and technology, a lot of these people would be hesitant. They don't even communicate in some cases with their former contacts in China.

So, I think that we may have -- I'm not going to say may. I think we did go too far in terms of the impact of some of these things and I think that we need to be very careful.

I made mention at the beginning of my presentation that the shortage of talent in the global semiconductor industry is a worldwide problem, and the only way we solve our problem here in the United States is by making sure there's a steady flow of students from Asia coming into the U.S. willing to work in that industry and help to drive it to the next level.

If we don't have that, I think we also will not be able to achieve our goals. And think about how many projects we have going on in the United States. Where is that talent going to come from? How are we going to meet the needs of those companies being set up, new plants, and research centers, and all of that?

It demands a huge amount of talent and I wonder has anyone sat down on the back of an envelope and even calculated how our needs are going to be met here domestically if we're not taking in Chinese students and giving them H-1B visas?

COMMISSIONER FRIEDBERG: Thank you very much.

COMMISSIONER PRICE: Thank you. And Co-Chair Cleveland?

COMMISSIONER CLEVELAND: Thank you both for appearing. I have several questions and I think we have a little bit of time today, so hopefully I can get through them.

Mr. Simon, I'm interested in your observation. In your testimony, you didn't speak to it, in your oral testimony, that managerial requirements at factory and R&D levels have been given little attention in terms of education, and that we are very focused on the science side, but when it comes to actually training people who can manage, that there's a lack of interest.

So, could you elaborate on what you see as the implications, particularly with the semiconductor industry, when it comes to teaching managers, training managers?

DR. SIMON: So, I've been studying the Chinese electronics industry for four decades and I was part of the generation of people who, you know, were asked can China innovate? No, China can't innovate. Can China produce state-of-the art? No, it can't, et cetera, et cetera.

And one of the conclusions I came to at the end of all of this is that the two areas of deficiency were one, the lack of a professional cadre of R&D managers. In the Chinese military, we have these R&D managers who manage big defense projects, and they understand how these work, and they know everything from budgets, to personnel, et cetera.

But in the civilian research side, that has been something that has been missing. We haven't seen that kind of professional cadre developed, nurtured, cultivated, et cetera. You would have thought that it would have happened in places like the Chinese Academy of Sciences and the 100 or so institutes under that.

But for seven years, I actually brought a delegation of institute directors and deputy directors to the United States to train them in three or four-week buckets about managing these kind of issues. And I would tell you, you know, there was a process called premature promotion in China.

Because of the impact of the cultural revolution, a lot of young people had to be promoted into more senior posts before they were ready, and therefore, they did not have that accumulated experience that one would have normally, let's say in the U.S., by having gone through the ranks and reaching that level.

So, I think right now in the semiconductor industry, this is the big problem. If you looked at it as a pyramid, you'd say okay, at the top are the most high-end talented managerial personnel who run these things, but you have to flip that pyramid on its head because the greatest need is also at that level because that's where they lack the experienced people.

Now, I mentioned at the end, they were hoping to get some of these people among Americans and Chinese-Americans, et cetera, that were going to work in China from Taiwan, maybe catch a couple from Korea, et cetera, but that seems now to be, that opportunity seems to be disappearing.

So, I think there's going to be a big gap in that area, and I don't see anywhere in China -- on the technology side, we see it. I described it, but I don't see anywhere in the management schools, whether it's Tsinghua, or Beida, or wherever, where they're actually explicitly preparing managers for high-tech careers in industries like semiconductor.

The technology management programs that exist in China really, even though they tried to copy a lot of what's gone on in the United States, they really don't catch what, you know, needs to happen, and particularly, because the managers are not deployed on the ground in factories.

They are too theoretical and not practical enough. So, I worry that that's one of the Achilles heel in the Chinese effort if they're trying to catch up.

COMMISSIONER CLEVELAND: Do you see that shortfall as a consequence of a party diktat, that they think that politics, or doctrine, or ideology is the answer to management? I mean, what do you see as the reasons why people just aren't interested in management?

DR. SIMON: In 2023, the answer is no. I think they understand. There is no reason to believe that the operation of a SMIC plant, or YMTC plant, or any one of those is experiencing any high level interference.

Sure, I think that there are party committees in all of these organizations, and when Xi Jinping makes his major speech at the latest party congress, everyone probably has a half a day of study session to make sure that they, you know, are cognizant of what the president has said.

But I think beyond that, it's all business, and I think that maybe at some lower level factories maybe in more state-owned enterprises, we see some of that more prevalent, but clearly not in the kind of state-of-the-art plants that we're talking about. I think it's all about business and I think it's all about the technology and competitiveness that they can achieve.

COMMISSIONER CLEVELAND: Thank you. We haven't spent a lot of time today talking about faculty in both of your presentations.

Can you talk a little bit about where faculty are drawn from, where they're trained, how they're trained, what the quality of that training may be, and then what kind of standards? Do they take tests in order to teach in universities? What's the faculty like?

MS. PETERSON: So, this is not an element that CSET has explicitly looked at as much, so I defer to Dr. Simon.

DR. SIMON: So, let me give two perspectives. In the 1980s, three percent of high school graduates went to university. That number then, by the late 1990s, grew to 25 percent, and today according to the latest data, over 51 percent of high school graduates can go to university.

So, you have to ask yourself if the enrollments in universities are increasing so rapidly, who is teaching these kids? That's a really big question.

And the reason why you have this bifurcation is clearly that at the top tier, they are getting not only their own graduates, which there's an incestuousness in the system. They tried to break it down, but the problem is that there are just not enough places to go.

The second source, of course, is getting people to come back after they've been in the U.S. or Europe for a number of years, and that's really why the talent programs have been so important for China is to recruit that faculty that are needed to staff these new positions across the entire system, and then also, of course, to drive the research.

So, there is a big problem. If the faculty -- the best and the brightest still stay in the United States, and if that's the case, then if you're getting a second tier, you know, coming from, I won't mention any U.S. university, but let's just say it's not the ivy leagues that they're coming back from, et cetera.

And so, what ends up happening is that they're not getting the kind of talent that they really want to have. That's why they've up -- you know, during the period before China Initiative at least, they had upped the stakes. You know, they were trying to get people by hook or by crook.

That's also why the program broke down, because they couldn't get people to make a decision to stay or go, so they gave them a choice. Come for a couple of months. We'll make believe you're here for nine months.

You know, we'll kind of break the rules, but we'll make it so it will work so that you can be here and you can be there and you don't have to give up your tenured job at a U.S. university.

But the reality is that they still aren't able to meet the needs of all of the faculty, and that's why at these bottom tier universities, they're not really going anywhere very, very quickly, but in the top ones, that's just the opposite.

That's why Tsinghua, Beida, and Fudan now have made the top 30 or 35 of world-class universities in the QS rankings, et cetera. It's because their faculty now are producing world-class students and world-class research that's simply not occurring at other places in the country.

COMMISSIONER CLEVELAND: Thank you. I have another round, but Commissioner Borochoff?

COMMISSIONER PRICE: Commissioner Borochoff?

COMMISSIONER BOROCHOFF: I would happily defer to you, Co-Chair Cleveland.

COMMISSIONER CLEVELAND: Go ahead.

COMMISSIONER BOROCHOFF: No.

COMMISSIONER CLEVELAND: Okay, all right, thank you. So, I'm curious, Ms. Peterson, if you heard this morning Dr. Ding's discussion about diffusion, and I'm wondering, given what you've characterized as these relationships between companies like iFlytek and

universities, whether you see the diffusion issue somewhat differently than he characterized it this morning?

MS. PETERSON: So, I would say that in terms of the AI partnerships, it's honestly a little early to tell because even with the AI major, I wouldn't -- so I want to note here that the AI major is actually not the only initiative that China has.

There's actually 34 other majors that China has that have the term like intelligentization in it, so those are a bit more AI adjacent, so like intelligent transport and things like that. So, it really is more context specific depending on your field of interest.

The AI one is a much more general field of study, but that has only begun in 2019, and so we haven't even seen actually the first group of four-year graduates come out. They will come out this spring.

And so, it's similar with the AI institutes. Those are both the research institutes and the colleges that are teaching the AI major and all of these other 34 related majors.

So we haven't seen concrete findings that have come out from these research -- it's a very difficult line to draw in the first place to say that this research was conducted at this institute and then directly translated into this innovation gain.

But that is ongoing work that I'm doing, studying what these research institutes are actually publishing, and so like are they focusing on more like natural language processing? Are they focusing on like ocean science? I'm particularly curious if they are, you know, focusing more on surveillance or military applications.

But I would also say that on a somewhat separate point, we are also looking and measuring the job demand for AI positions in China, and so we can see that there are, you know, the four major hubs that are classically associated with the top economic hubs in China, so including Guangdong and Zhejiang in the Beijing region, Chongqing, like those areas are huge vacuums for AI talent.

So, that is also not necessarily to say that there is diffusion that is occurring, but those are very interesting areas to watch to see what emerges out of those hubs of AI activity.

COMMISSIONER CLEVELAND: When you say vacuum, you mean concentration. You don't mean --

(Simultaneous speaking.)

MS. PETERSON: Yeah, I mean that they are vacuuming them across --

COMMISSIONER CLEVELAND: Right, okay.

MS. PETERSON: -- from different regions in the country and leaving them to potentially have talent shortages.

COMMISSIONER CLEVELAND: Elsewhere, okay.

DR. SIMON: I want to just add one point quickly. One of the problems that we see in semiconductor is this rapid turnover of personnel.

Now, if you're a company, you obviously don't like rapid turnover of personnel, but if you're looking at diffusion of knowledge, the movement of people, the high level of talent mobility is something actually that could turn out to be beneficial because people bring -- legally, or illegally, or whatever.

Let's just assume for the moment they didn't steal the IP, but it's embedded, you know, that they brought with them the knowledge that they have, and then they are able to upgrade what's going on at the next place and the next job place.

That actually turns out to have some beneficial effects even though the original company is not happy that they lost their, you know, job candidate, or invested money in the training of their job candidate.

There is this phenomena they say that there are hot companies and cold schools, where the schools are not interested, but the companies are really interested, but there's also the opposite, cold companies and hot schools, schools that want to get their kids employed, but the companies are so nervous they're going to lose them after six months or a year because of the turnover rate, but the positive if you step back is that that does provide a vehicle for diffusion of knowhow across the economy.

COMMISSIONER CLEVELAND: I think you anticipated one of my questions, the next question, which is you mentioned in your testimony that 236,000 employees were recruited from the market versus 67,000 coming from campuses.

And I noticed yesterday, there was a story on the slide of several big tech, PDD, Alibaba, I think Meituan was one of them, of their stock value because they are competing for employees.

Can you talk with a little more granularity about that, those two points, that it's just people moving within the market rather than coming out of schools into these companies, and where is there the most mobility? Is it early stage career? What does it look like?

DR. SIMON: So, my sense is that the companies go to the marketplace because they're looking for experienced talent. That's what they want.

They don't like getting these newbies because many of them don't meet the initial expectations. I thought you could do A, B, C, and D, and you really can't do that, and I think you heard some this morning.

Some of it's apocryphal, but I think the reality is that in something like this, they want to put you right to work very quickly to add value, and if you can't do that, then basically you're not very worthwhile. So, I think they, the companies, the private companies in particular, are in the marketplace.

The state-owned enterprises, I think there is some more pressure on them to go to the universities and to hire those people simply because they're much more a part of the system, and therefore, I think they feel some obligation to do that, but even more importantly, they want to develop a steady pipeline so that they have people that are available. Even if they're not the best people, they've got people and then they can work them through their system.

I think that that's going to continue to be the case. I think that we're going to -- you know, as we see with the proliferation of companies as a whole, particularly on the IC design side, that's what's made that market so lively.

There's just been such a big proliferation and they don't know where they can get the talent from. That's why these auxiliary vocational type schools have emerged, but there's again good news and bad news with those. Some are very good and some are not so good. Why?

Because if you're going to be very good, you're going to have to hire faculty who can teach at the state of the art, and those people command a very high salary, which means then you've got to charge a high tuition, which means then you've got to guarantee a job at the end or else the applicant is not going to want to pay 30,000 or 40,000 yuan to get this kind of specialized training.

We had this in the United States, if you remember, with respect to programmers. We had it particularly I know on the West Coast, but I saw it also on the East Coast, a number of schools emerge, six-month training, pay the equivalent of a university education for one year, but most of them, those graduates were working at Google, and Amazon, and wherever after they finished.

In China, there's no guarantee like that, and so I think the students are a little bit dubious and the employers are a little bit dubious. So, that's why in the marketplace, they can have a wider range of people to take a look at.

And so, you've also seen a proliferation of headhunting firms, you know, who basically are looking for talent, and people tell me they get phone calls all the time. Are you thinking of losing your job, not losing, moving your job or shifting your job?

So, I mean, the word chaos or chaotic is a good word because it is a little bit chaotic, and it may be short term because the Chinese now are feeling the impact of the U.S. restrictions immediately almost.

Maybe in two or three years, it will sort itself out a little bit. Supply and demand, you know, will seem to work itself out, but I think that all has to do with how fast they can improve the curriculum and the delivery of that curriculum to the students.

COMMISSIONER PRICE: My questions have been answered, so let me ask everyone else if anyone else has any additional questions before we go back to Robin, Commissioner? Anyone else have anything else they want to ask? Anyone remotely? Okay, it's all yours.

COMMISSIONER CLEVELAND: Just one more question. Since this is a hearing on education and training and the future of the workforce, I'm interested in if you know, Ms. Peterson, how AI is being used to enhance education and training?

MS. PETERSON: Yes, that's like a complementary effort. So, I did mention in response to one of my questions earlier that there are major platforms such as Baidu that is really trying to bring AI-enabled education.

So, it's a bit of a parallel concept where it's the virtual assistant type of approach. So, that is actually quite widespread, and bringing that to rural areas, that's meant to pose as an assistant, as a complementary method to rural teachers, to urban teachers.

And so, measuring the effectiveness of that is pretty much almost impossible, but it is something, and it is also something that I would say exists in the U.S. in a little bit of a different form where that's a big more in person.

So, one of our CSET research efforts has quantified the portfolio of summer camps, and after schools, and things like that to enhance AI education as well.

But this is another facet that is not necessarily, I wouldn't say it's as explicitly called upon in the strategic plans, but it is one of the effects of how industry is trying to help build interest in sharpening the --

So, I think this kind of goes back to the first panel a little bit in talking about the lack of educational base that some students have, especially in rural areas.

So, in theory, it seems like if it's -- the AI-enabled education methods are supposed to help fit each of the students a little bit better and tailor it to their learning style across a wide range of subjects, right, so like English, math, science, all of these other topics.

I think that is something that might help them, but it's still, at the end of the day, those really critical shortages, and that very persistent rural-urban divide is not something that I believe is necessarily solvable through just access to a learning platform.

DR. SIMON: You know, under normal circumstances, the market would have been filled with AI summer camps and AI programs, et cetera, but after the crackdown on companies like New Oriental, et cetera, there was a desire to make sure that there's not just, you know, wealthy kids can go to these and the rest of the country is left behind.

So, I think that, you know, we may see a different model develop where it's not just entrepreneurial, you know, people who are trying to open up a new business by creating these camps. I think it may become part of an auxiliary element as part of the education system.

My sense is that the Ministry of Education has been told, you know, do not forget rural education, that we don't want to have a bifurcated country. We don't want to have, you know, the 14 coastal city part of the country, you know, on the East Coast and then everything else.

We know that in 1949, that produced a revolution, so preventing the bifurcation of the Chinese economy in terms of quality of life, healthcare, educational access, et cetera.

That's why, you know, going back to your session this morning, the big point about the role of the Gaokao should really not be ignored.

I was the Executive Vice Chancellor for Duke Kunshan University for five years, one of the four Sino-U.S. joint venture universities, and actually was the one that developed our admissions policy for letting in the Chinese students through Gaokao.

And I do have to say, you know, even though there are some shenanigans, you know, that are in the backdrop, more or less, the system has a high degree of integrity.

For Americans, we don't like it because we can't craft a class. You know, if you're at Duke or you're at somewhere like that, you know, you look across, you look at all sorts of things in terms of the background of the students other than just the SAT or ACT tests, and some schools no longer even require those tests, but in China, the only way to get close to any kind of equitable access is the use of this kind of testing mechanism, so that's why it hasn't disappeared.

You know, lots of stuff has been reformed in China and lots of stuff has gone away, but the major vehicle by which you have upward mobility in China still is the Gaokao. The question is how can they improve what the Gaokao is as an education tool so it doesn't end up with students who have just rote memory?

In the first batch of students we got at DKU, 60 percent were from China and that was the quota that we wanted. The one thing that students told us -- and DK is a liberal arts oriented joint venture university.

They said the thing that we found in the first several weeks is that we were asked a question that we were never asked in our other education experience. I said oh, what's that question? What do you think? What do you think?

So, that became the cry, you know, so what do you think, and how do you tell somebody how you think in an educated and informed way? And I think that's something I think China wants to cultivate.

They just want to cultivate it within certain guardrails, you know, but I think that the problem with China always is it's never a zero one. It's somewhere in the spectrum of finding a balance where we would be comfortable with the balance, but they want to find some balance.

They clearly know that and I think we see the improvement in the research environment really demonstrating the effort to give more degrees of freedom to the scientific and technical community to do their thing.

And that's why you have technological entrepreneurs, you know, who have proliferated, even with the crackdown that went on, you know, a year, year and a half ago. The reality is that there's no dearth of people with creative ideas in China.

I think we would be making a big mistake if somehow we thought that creativity never emerged or it's dead in China. I think that would not do us well as we look at the future of our relationship.

COMMISSIONER PRICE: If there are no other questions, then in conclusion, I want to say as I did at the beginning that we'd like to remind you all that testimonies and transcripts from today's hearings will be posted on our website. I also recommend to you the paper that was submitted by Dr. Hannum to the Commission as well. It has interesting additional information.

Please also mark your calendars for the Commission's upcoming hearing on China's global influence and interference activities. That's going to be on March 23.

So, I want to thank all of our witnesses, both Dr. Simon and Ms. Peterson for this panel, and all of our previous panels, the Commissioners for all of your attentiveness and participation, the staff who did so much important preparation, and we are adjourned. Thank you.

(Whereupon, the above-entitled matter went off the record at 2:15 p.m.)

REPORT PREPARED FOR THE COMMISSION

REPORT BY EMILY HANNUM, DEPARTMENT OF SOCIOLOGY AND POPULATION STUDIES CENTER, UNIVERSITY OF PENNSYLVANIA

Educational Development in China: Progress, Challenges, and Outlook

Report prepared for the U.S.-China Economic and Security Review Commission

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Abstract

This report provides a desk review of recent educational policy priorities and developments in China. The report first provides a brief background on the development of the educational system today and introduces current administrative structures and national policy priorities for education. It next introduces important aspects of the context in which the educational system functions, with attention to challenges associated with emerging economic and demographic trends. The report then reviews recent policies and developments, organized by level of schooling. For each level of schooling, the report touches on current policies and policy goals and discusses available data and selected scholarly findings regarding progress in implementing policy goals, equity issues, and quality. The report also discusses available evidence regarding incorporation of EdTech and AI in education. The report closes with a summary of key elements of progress in China's educational development and a reflection on challenges ahead.

Keywords: Educational policy, educational systems, educational development, China

Contents

1 Introduction

1.1 Purpose of the report

This report provides an overview of recent educational policy priorities and developments in China. The report summarizes key policies and guidance documents, with respect to each stage of education, considers available evidence about progress and challenges in reaching policy goals, and considers the outlook, looking ahead.

1.2 Structure of the report

The structure of the report is as follows. It will first provide brief background on the development of the educational system today and then introduce current administrative and leadership structures and national policy priorities. It will next introduce important elements of the context in which the system functions, with attention to challenges associated with economic and demographic trends. The report will then turn to an overview of recent policies and developments, organized by level of schooling. For each level of schooling, the report will touch on current policies and policy goals and discuss available data and scholarly findings regarding progress in implementing policy goals, equity issues, and quality. The report will also discuss policies regarding EdTech and AI in education. The report will close with a summary of key elements of progress in China's educational development as well as challenges ahead.

2 Background

2.1 Development of the current educational system

Expanding access to basic education was a priority in the early ears of the People's Republic of China. Educational provision expanded rapidly in urban and rural areas (Hannum 1999). In the late 1950s and early 1960s, radical policies of the Great Leap Forward and an associated famine caused massive disruptions; in the mid-1960s to the mid-1970s, the Cultural Revolution brought a radical egalitarianism and an educational push into the countryside (Hannum 1999). At the end of the 1970s and into the 1980s, China embarked on market transition. A 1986 law decreed the roll-out of a 9-year period of compulsory schooling and offered guidelines on financing and other regulations (Pan, Vayssettes, and Fordham 2016). The law stipulated this right regardless of "gender, race, ethnicity, family socioeconomic status, or religious beliefs" (National People's Congress 1986), but children with disabilities were not explicitly assured of these rights in the 1986 law (An, Hu, and Horn 2018, 118).

In the early 2000s, policies continued to target cost barriers to basic education. The Compulsory Education Law was revised in 2006 (National People's Congress 2006), with guidelines prohibiting miscellaneous fees[1](Pan, Vayssettes, and Fordham 2016, 12). An, Hu, and Horn (2018) report that

1. The wording in the law itself does not specify the meaning of miscellaneous fees. It states, "No tuition or miscellaneous fees shall be charged for provision of compulsory education," suggesting that the strategy of charging what might be considered tuition by another name is not allowed (National People's Congress 2006)

the 2006 re-authorization of the compulsory education law (National People's Congress 2006),[2] and a Law on the Protection of Disabled Persons (National People's Congress 2008, article 21) stipulate the rights of persons with disabilities to education.

Paralleling developments in other parts of East Asia, curriculum reforms in the early 2000s sought to promote more holistic, student-centered learning (Hannum et al. 2019; Sargent et al. 2011; Sargent 2009). China began to address the demographic challenges of falling fertility and urbanization by a massive school consolidation push in the countryside starting in 2001 (Hannum, Liu, and Wang 2021; Hannum and Wang 2022). Finally, higher education was aggressively expanded in the early 2000s (Xiong, Yang, and Shen 2022). China also espoused a major policy initiative to universalize pre-primary education by 2020 (Pan, Vayssettes, and Fordham 2016, 11), has prioritized reforming vocational and technical education, including expanding corporate partnerships for apprenticeship training, and has set out plans for incorporation of smart technology and AI in education across levels (Australian Embassy in Beijing and Department of Education of Australia 2021).

Finally, as in all societies, social and economic inequalities shape educational opportunities and experiences. Children in poor households and communities, children in remote rural areas, children affected by migration, children with health problems or disabilities, and children from some of China's officially-recognized ethnic minority communities can face challenges in securing full access to high quality educational experiences, compared to others. These issues have continued to shape national policy agendas (National Working Committee on Women, National Bureau of Statistics, and UNICEF China 2018a, 108).

2.2 Administration and leadership of the educational system

This section relies in full on a thorough overview of national educational administration and leadership in China provided in Liu and An (2020). There are five leading entities in China's political

2. Article 6 states, "The State Council and the local people's governments at or above the county level shall rationally allocate educational resources, promote balanced development of compulsory education, help the schools started on weak foundations to improve the conditions for school running, and adopt measures to ensure that compulsory education is provided in rural areas and in areas inhabited by ethnic groups and that the school-age children and adolescents who are from families with financial difficulties or who are disabled receive compulsory education." Article 19 states, "People's governments at or above the county level shall, in light of need, establish schools (classes) to provide special education that is appropriate for school-age children and adolescents who are blind, deaf-mute or [developmentally delayed] to receive compulsory education. Such schools (classes) shall have places and facilities tailored to the special characteristics of the said children and adolescents for the benefit of their study, rehabilitation and daily life.

Regular schools shall admit to the classes corresponding to the levels of the disabled school-age children and adolescents who are capable of receiving regular education and provide them with aid in study and rehabilitation."

system: the Communist Party of China (CPC) Central Committee,[3] the State Council,[4] the National People's Congress (NPC),[5] the Chinese People's Political Consultative Conference (CPPCC) National Committee,[6] and the Central Military Commission[7] (Liu and An 2020). These entities "constitute the decision-making system ... at the national level and thus have a strong impact on the governance and management of educational institutions" (Liu and An 2020, 8–9). China's Constitution and a series of regulations issued by the Communist Party of China (CPC) Central Committee and the State Council provide the foundation within which the central government and local governments have set up structures of educational leadership and administration for education in China (Liu and An 2020, 8–9):

> ... [T]he Constitution of the PRC and The Educational Law of the PRC make legal provisions for the administrative system of education in China. The Constitution stipulates that the State Council guides and governs the work of education. Local governments at or above the county level within the restraints of authority regulated by law are in charge of the educational cause in their respective administrative areas. The Educational Law specifies that the State Council and local people's governments at various levels shall lead and govern the work of education in accordance with the principles of hierarchical management[8] and division of responsibility ... Primary and secondary education [are] administered by local people's governments under the leadership of the State Council. Higher education is managed by the State Council and the people's governments of provinces, autonomous regions, and municipalities directly under the central government.

3. The CPC Central Committee is the top leadership entity of the Communist Party. The fundamental policies of the CPC Central Committee "become national will through the NPC and its Standing Committee" and are implemented by the State Council (Liu and An 2020, 9). Liu and An (2020, 9) report that "[s]ome important educational reform and development policies are made in the name of the Central Committee of the Communist Party of China, while more educational reform and development policies are made according to the procedures and guiding ideology of the Central Committee."

4. The State Council is the top administrative entity and the top implementing entity for policies and decisions made by the National People's Congress; it guides and governs the work of education(Liu and An 2020, 8–9).

5. The National People's Congress is the top organ of state power, has national legislative power, and is responsible for enacting and amending the constitution and fundamental laws, among many other responsibilities. Education laws and important educational reform and development policies are usually passed by the National People's Congress (Liu and An 2020, 10).

6. The Chinese People's Political Consultative Conference (CPPCC) National Committee is an entity for political consultation with other parties and non-party people on national fundamental policies and other key issues (Liu and An 2020, 10).

7. The Central Military Commission is only responsible for military higher education (Liu and An 2020, 10).

8. The source explains, "[H]ierarchical management means that all levels of people's governments have different management responsibilities for education at all levels. Division of responsibility means the government departments at the same level — such as education, finance, national development and reform, personnel, audit, etc. — shoulder different responsibilities for the educational cause based on their duties" (Liu and An 2020, 8–9).

2.3 Current national priorities in education

A guiding document in current, national educational priorities is China's *Education Modernization 2035 Plan*, the broad goals of which include the below items (see Australian Embassy in Beijing and Department of Education of Australia (2021) and Zhu (2019, 357):

1. Establishing a modern education system
2. Achieving universal attendance in quality pre-school education
3. Providing high quality and balanced compulsory education
4. Achieving maximum attendance in senior high school
5. Significantly improving vocational education
6. Building a more competitive higher education system
7. Providing adequate education for disabled children/youth, and
8. Establishing a new education management system with participation from the whole society (i.e. not solely relying on government support).

A few months after the release of the 2035 Plan and Implementation Plan, one report indicates that the Ministry of Education issued a joint circular together with 10 other central government agencies to set the direction for online education development (Australian Embassy in Beijing and Department of Education of Australia 2021). The document offered guidance for improving China's online education infrastructure, with the Internet, big data and Artificial Intelligence (AI) set to be used more widely in education (Australian Embassy in Beijing and Department of Education of Australia 2021).

The goals of the 2035 Plan are very consistent with the educational priorities articulated in "Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035" (National People's Congress 2021), commonly referred to as China's 14th Five-Year Plan. The value attached to education in this national strategic planning document is indicated by the presence of an educational goal — increasing the education of the workforce from 10.8 years in 2020 to 11.3 years in 2025[9] — as a "binding" indicator among the main social and economic development goals set out in section 1 of the document (National People's Congress 2021, Table 1, 10).

In part 5 of the document, entitled "Accelerate digitalization-based development and construct a digital China," the document sets out a commitment to "smart education" in "Digitalized application scenarios:" "We will promote the integration of socialized (社　化, *she hui hua*), high-quality, and online course resources into the public teaching system, we will promote the online radiation of high-quality educational resources to weak schools in rural areas and remote areas, and develop

9. No information is provided in the source about the rationale for or significance of this specific educational benchmark.

scenario-based and experiential learning and intelligentized education management evaluation" (National People's Congress 2021, Table 9, 45).

Finally, part 13 of the document, "Improve the quality of citizens (民素 , *guo min su zhi*) and promote comprehensive human development," contains section XLIII, "Construct a high-quality educational system" (National People's Congress 2021, 104). In a table entitled, "Educational quality increase and capacity expansion projects," five commitments are made (National People's Congress 2021, Table 16, 107):

1. **Inclusive kindergartens:** Focusing on areas where the population is concentrated, rural areas, and the "Three Regions and Three Prefectures" (三 三州, *san qu san zhou*),[10] we will build, renovate, and expand 20,000 kindergartens and add over 4 million inclusive enrollment slots.

2. **Basic education:** Focusing on counties with weak educational foundations and population inflow areas, we will build, renovate, and expand 4,000 primary and secondary schools. We will construct 100 "national door schools" (校, *guo men xue xiao*) in border counties (and Xinjiang Production and Construction Corps farms (, *tuan chang*).

3. **Vocational and technical education:** We will support the construction of 200 high-level vocational schools and more than 600 high-level majors and support the construction of a number of excellent secondary vocational schools and high-quality majors.

4. **Higher education:** We will strengthen "double first-class"[11] construction of basic research and collaborative innovation capabilities of colleges and universities, improve the operating conditions of 100 undergraduate colleges and universities in the central and western regions, and lay out and build a number of high-level public health colleges and high-level normal colleges.

5. **Production and education integration platforms:** Focusing on key areas such as ICs, AI, industrial internet, and energy storage, we will lay out and build a batch of national innovation platforms for the integration of production and education and joint training bases for graduate students. We will build 100 high-level, professional, and open training bases for the integration of production and education."

The document also places emphasis on cultural preservation, patriotic education and party education, and moral education.

10. This term refers to highly impoverished areas – "the "three regions" are Tibet, the Tibetan ethnic areas of Sichuan, Yunnan, Gansu and Qinghai provinces, and the four prefectures in southern Xinjiang (Hotan, Aksu, Kashi and the Kizilsu Kirgiz Autonomous Prefecture). The "three prefectures" are Liangshan in Sichuan, Nujiang in Yunnan and Linxia in Gansu"(China.org 2021).

11. This English-language source uses the term "world class" in place of "first class." I have changed the translation in the main text to be "first class," with the intent to be consistent with other sources later in this report. A translator's note in the cited source explains that the PRC government launched its "world-class universities and world-class curricula" (世界一流大 和一流 科, *shi jie yi liu da xue he yi liu xue ke*) initiative, abbreviated "double world-class" (一流, *shuang yi liu*), in 2017 with the aim of increasing the number of Chinese universities that rank among the world's best. See discussion below, in the section entitled, Tertiary Education.

Xi Jinping's October, 2022 report to the 20th National Congress of the Communist Party of China reaffirmed these commitments (Xi 2022, 20). The report highlighted as a goal to "[b]ecome a leading country in education, science and technology, talent, culture, sports, and health; significantly enhance national soft power" (Xi 2022, 20). The document contained a section entitled, "Invigorating China through Science and Education and Developing a Strong Workforce for the Modernization Drive," which starts with the sentence, "Education, science and technology, and human resources are the foundational and strategic pillars for building a modern socialist country in all respects" (Xi 2022, 28). The document highlights the goal of "fostering virtue through education, and [nurturing] a new generation of capable young people with sound moral grounding, intellectual ability, physical vigor, aesthetic sensibility, and work skills who will fully develop socialism and carry forward the socialist cause" (Xi 2022, 28).

The document stresses "high-quality, balanced development and urban-rural integration in compulsory education," strengthening preschool education and special needs education, ensuring the diversified development of senior secondary schools, promoting collaboration and innovation in vocational education, and improving the financial aid system so it covers students at all stages of schooling. The document pledges support for the development of basic disciplines, emerging disciplines, and interdisciplinary subjects, and building up world-class universities and strong disciplines, with Chinese features. Promotion of standard spoken and written Chinese is a priority. Finally, the document supports development of new teaching materials, systems for school management and educational assessments, and mechanisms for school-family-society collaboration, endorses digitalization of education, and embraces the notion of lifelong learning for all (Xi 2022).

2.4 Adapting to new contexts

2.4.1 New economic realities

China transformed since the late 1970s from a relatively poor but highly egalitarian society to a much wealthier but highly unequal one. For much of the 21st century to date, China achieved rapid economic growth and paired that growth with highly ambitious poverty reduction activities that led to a reduction in extreme rural poverty by national estimates from half of the rural population in 2000 to 0 percent in 2020 (International Monetary Fund and National Bureau of Statistics of China 2023; National Bureau of Statistics of China 2023e). A detailed recent report on poverty alleviation in China published by The World Bank and Development Research Center of the State Council (2022, ix) opens with this assessment:

> Over the past 40 years, the number of people in China with incomes below 1.90 USD per day has fallen by close to 800 million, accounting for close to three-quarters of global poverty reduction since 1980 ... By any measure, the speed and scale of China's poverty reduction is historically unprecedented.

In the most recent period, China's growth has faltered (International Monetary Fund and National Bureau of Statistics of China 2023). Inequality has remained relatively high, though estimates from different sources differ on the absolute level and whether it is declining or increasing in recent

years. National estimates of China's GINI coefficient since 2004 show a range between about 46 to 49, with a value of 46.6 in 2021 (National Bureau of Statistics of China 2023d). Estimates based on the high-quality China Family Panel Surveys show higher levels than national estimates and an increasing trend, but estimates are not available for the most recent years (Mazzocco 2022).[12] For the sake of comparison, the Gini coefficient for the United States in 2020 was 41.95 (Statista and Bank 2021).

It is important to note that economic disparities in China have longstanding regional and urban-rural dimensions. For example, in terms of household per capita disposable income, the east coast region figure of ¥44,980.30 in 2021 (approximately $6,630)[13] is 1.47 times the corresponding figure for the northeast, China's rustbelt; 1.52 times the figure for central China; and 1.62 times the figure for the poorest western region (National Bureau of Statistics of China 2022). Nationally, the urban average on the same metric for the year 2022 was ¥49,283 (approximately $7,265), which was a full 2.45 times the rural figure in the same year (National Bureau of Statistics of China 2023c). For education planners, economic inequalities, including regional and urban-rural economic gaps, present important challenges to the equitable provision of education.

Also very relevant to educational planning is the concern about a poor job market for urban youth and for college graduates. Reports as recent as 2018 suggest that 91 percent of bachelor's graduates and 92 percent of vocational higher education graduates were employed (Textor 2023), but recent reports suggest that the monthly urban youth unemployment rate was nearly 20% in July 2022, while being slightly lower at about 17% in December 2022 (National Bureau of Statistics of China 2023b). The youth figures are much higher than corresponding figures for the general urban population. For example, the monthly urban unemployment rate for December 2022 was 5.5% (National Bureau of Statistics of China 2023a). The poor job prospects for urban youth are coinciding with unprecedented numbers of college graduates due to expansion in higher education. News reports indicate that a record 11.58 million college graduates are projected to join a very difficult labor market in 2023 (Reuters 2023).

2.4.2 New demographic realities

China's total fertility rate[14] has declined very dramatically since about 1970; it peaked *before* the implementation of the later-longer-fewer campaign in the 1970s and then the one-child policy (UN DESA 2022, 2023). The fertility rate fell to an all time low by the early 2000s and, despite loosening of fertility restrictions in recent years, was projected to be 1.19 in 2023 by the United Nations (Silver and Huang 2022; UN DESA 2023). Declining fertility, rising life expectancy and a progression of larger cohorts to older ages has brought rapid population aging in China (for a summary and statistics, see Textor (2022a).) China's working age population peaked around 2015 and has started to decline, while the elderly population share is rising, creating an increasing aged

12. A study spanning the years 1988 and 2013 indicated that national income inequality rose markedly to 2007 and thereafter fell slightly (Luo, Li, and Sicular 2020). The most recent World Bank estimate, for 2019, is lower, at 38.2 (World Bank 2023).

13. Dollar estimate uses an exchange rate for January 24, 2023 of 1 CNY = 0.147405 USD (XE.com 2023).

14. The total fertility rate is the point-in-time snapshot of the average number of children that women would have if they passed through reproductive years at prevailing age-specific fertility rates.

dependency ratio (Textor 2022a; UN DESA and Textor 2023). The child population is also declining (UN DESA and Textor 2023), and in rural areas, fertility decline and outmigration are leading to sparse school-age populations in many communities and many children being "left behind" by parents migrating to cities (Hannum, Liu, and Wang 2021; Hannum and Wang 2022; Shen, Hu, and Hannum 2021).

It is important to note that China achieved the difficult feat of broad-based educational expansion during a period of *growing* child cohorts, creating a "demographic dividend" in the form of a growing fraction of the population being both working age and educated. This circumstance is reversing as the working population and the school-age population decline and China faces demographic headwinds — sometimes referred to as a "demographic burden." Now facing ever *fewer* workers and *fewer* students, the national educational challenge is to reconfigure education to meet the needs of a rapidly-evolving economy with a declining workforce. In rural areas, where depopulation is also occurring due to outmigration, an additional challenge is to develop an educational delivery model that effectively and efficiently reaches rural communities with now-sparse school-age populations and many families in which the parent generation is gone.

3 Key policies and developments by level of schooling

3.1 Pre-primary education

A 2018 UNICEF report states that in the years 2011 and 2016, China "implemented two rounds of the Plan of Action for Pre-primary Education at the county level, and these efforts ... led to the continuous improvement of pre-primary education for children aged 3 - 6" (National Working Committee on Women, National Bureau of Statistics, and UNICEF China 2018a, 108). According to the same source, continuing concerns about access and quality led to initiation of "a third round of the Plan of Action for Pre-primary Education (2017 - 2020)" and efforts to set up a public service system for pre-primary education with broad coverage, and wide access and basic quality by 2020." (National Working Committee on Women, National Bureau of Statistics, and UNICEF China 2018a, 108). Making pre-primary education high quality and inclusive remains a policy priority, as discussed in the section, "Current national priorities."

As a crude indicator of progress on expansion, gross enrollment ratio data show a long-term upward trajectory in pre-primary enrollment, with very rapid increases around the time of these action plans, after a dip in the early 2000s (World Bank 2022).[15] As a crude indicator of quality, pupil-teacher ratios at the pre-primary stage have been dropping precipitously since 2010 (World Bank 2020). What were once large urban-rural and regional access gaps have narrowed in this recent period of policy focus. A UNICEF report shows that gaps in rates of use of pre-primary school before primary school entry have dwindled to a few percentage points, with rates from the mid- to high-90s (National Working Committee on Women, National Bureau of Statistics, and UNICEF China 2018b).

15. The reported gross enrollment ratio in China is now higher than the corresponding figure in the United States (World Bank 2022).

3.2 Primary and secondary education

3.2.1 Compulsory education

Compulsory education in China consists of primary and lower secondary education, and national policy has long prioritized a strategic goal of universal access to free compulsory education (see National Working Committee on Women, National Bureau of Statistics, and UNICEF China (2018a, 108); see also UNESCO (2021)).

Primary education access has been very high for decades, with net enrollment ratios[16] climbing from 97.8% in 1990 to above 99.96% in 2020 (Ministry of Education of China 2021b). Net enrollment ratios are not available for other levels of schooling, but gross enrollment ratios are available.[17] The lower secondary gross enrollment ratio grew from 66.7% in 1990 to 88.6% in 2000 to over 100% by 2020, where it has remained throughout the period of observation (Ministry of Education of China 2021a).[18] However, an OECD benchmarking report indicates that the gross graduation ratio[19] from lower secondary education declined from 97.98% in 2013 to 86.01% in 2018 (OECD 2020, 40).

Demographic shifts — declining fertility, rural-to-urban migration, and family separation due to parental outmigration — have created new challenges to rural educational systems. Consolidation of small schools and boarding at consolidated schools are common solutions to sparse rural cohorts of children and the left-behind children phenomenon (Hannum, Liu, and Wang 2021; Hannum and Wang 2022). A UNICEF report indicated that in 2017, 10.66 million primary school students and 20.74 million junior secondary school students were boarders —these figures represent 10.6 per cent of all students in primary schools and 46.7 per cent of those in junior secondary schools (National Working Committee on Women and National Bureau of Statistics of China and UNICEF China 2018). The same report highlighted significant extra exposure to boarding in rural areas and in central and western regions. Notably, in 2017, the proportion of students who were boarders in junior secondary education exceeded 80 per cent in rural areas of the Guangxi Zhuang Autonomous Region, the Tibet Autonomous Region, and Yunnan Province (National Working Committee on Women and National Bureau of Statistics of China and UNICEF China 2018).

3.2.2 Upper secondary education

After completing lower secondary education, students are required to take an upper secondary education entrance exam (中考, *zhongkao*) to participate in upper secondary education (OECD 2020, 36). Upper secondary can be general education or vocational education. Overall, educational access at this level has risen dramatically over time. China's long-term educational expansion at

16. The net enrollment ratio is calculated as the total number of students in the theoretical age group for a given level of education enrolled in that level, expressed as a percentage of the total population in that age group(OECD 2020, 37).

17. The gross enrollment ratio is the number of students enrolled in a given level of education, regardless of age, expressed as a percentage of the official school-age population corresponding to the same level of education (OECD 2020, 37).

18. Gross enrollment ratios can go over 100% when there is over-age or under-age enrollment at a given level.

19. The OECD defines the gross graduation ratio as "Number of graduates regardless of age in a given level or programme, expressed as a percentage of the population at the theoretical graduation age for that level or programme." The benchmarking report utilizes this measure as a proxy for student completion (OECD 2020, 37).

this level is reflected in the attainment of the adult population. The percentage of the Chinese population aged 25 and older that has reached a secondary level of education grew from 36% in 1990 to 52.3% in 2000 to 65.3% in 2010 to 79.2% in 2019 (UNDP 2021). A more timely indicator is the senior secondary gross enrollment ratio, which grew from 26% in 1990 to 42.8% in 2000 to 82.5% in 2010 (Ministry of Education of China 2022a). By the most recent available year of data, 2021, the ratio had reached 91.4%. UNESCO Institute for Statistics estimates of upper secondary gross enrollment ratios are slightly lower, at 76.8% in 2010 and 84.6% in 2021, with some ups and downs in between (UNESCO Institute for Statistics 2023).[20]

An important priority in education policy documents has been promotion and improvement of vocational and technical education. In 2021, about 26 million students were enrolled at at senior high schools in China (National Bureau of Statistics of China and Ministry of Education of China 2022b). Corresponding figures for secondary vocational schools were that around 13.12 million students were enrolled in 2021 (National Bureau of Statistics of China and Ministry of Education of China 2022d). However, this number reflects a declining number and share of students choosing vocational education. A challenge has been stigma attached to vocational schools and students and significant concerns about the quality of learning experiences in vocational education (Loyalka et al. 2016).

A major vocational education reform was set out in 2019 (State Council 2019). China's priorities in vocational education reform were discussed in a recent policy report by the Australian Embassy in Beijing (Australian Embassy in Beijing and Department of Education of Australia 2019). These included establishing national standards for vocational education, ensuring greater applied/technical learning and practical training, incorporating military-related vocational education into the national vocational education system, constructing a qualifications certification system and banking system for vocational education credits, promoting the integration of vocational schools with industry, establishing vocational education evaluation organizations, and improving funding mechanisms. Medium and large-sized private enterprises are set to run apprenticeships from a range of sectors that reportedly include agricultural, manufacturing, ICT, automotive and shipbuilding, aerospace, steel and metallurgy, energy and transportation, energy-saving and environmental protection, construction and assemblies, finance, and social services (Australian Embassy in Beijing and Department of Education of Australia 2021, 5).

Another document, *Opinions on Promoting High-quality Development of Modern Vocational Education*, was issued in October 2021 by the General Office of the CCPC Central Committee and the General Office of the State Council, (see Xinhua (2021a) for an announcement; see details and discussion in (Department of Education, Skills and Employment of Australia 2022)). The document reportedly prioritizes developing a modern vocational education system by 2025 and positioning China among the world's top countries for vocational education by 2035; reported strategies include "promoting greater international collaboration and exchange with 'quality partners', and

20. These discrepancies may emerge due to some combination of discrepancies in a) the age range used as the standard range eligible to be enrolled at this level, b) the estimate of the population in that age range, or c) the estimate of enrolled students.

giving more weight to vocational education in government-supported inbound and outbound studies" (Department of Education, Skills and Employment of Australia 2022).

3.2.3 Pandemic and recovery

China was the first country to implement nationwide school closures during the Covid crisis — the closure covered the entire education system at all levels, and is estimated to have affected 278 million students (OECD 2020, 144). When Covid broke out in early 2020 in Wuhan, students were out of school on winter vacation, and the Ministry of Education initially announced a delay in the school opening date of the spring semester on January 27, 2020 and then issued a notice "suspending classes without suspending learning" (停　不停　, *ting ke bu ting xue*) on February 12, 2020, which required primary and secondary school students to continue their studies at home (see source documents Ministry of Education of China (2020) and Ministry of Education of China and Ministry of Industry and Information Technology (2020), cited and described in Liao, Ma, and Xue (2022, 3)). The guidance was then implemented by provincial-level governments in a decentralized way: provincial governments made their own plans on how to conduct online education and when to reopen schools. China was also one of the earliest countries to develop school reopening plans (OECD 2020, 144).

At the outset of the pandemic, the OECD (2020, 145) reports that educational systems started coordinating online learning resources at national, regional and school levels, "with the intention of bringing together all existing learning resources, and making them public on one integrated, nationwide, online learning platform." The central education authority required local authorities to develop and provide new locally-relevant online learning classes. For areas with poor internet access, China's education system built "horizontal capacity" in the form of television broadcasts of learning resources, such as recorded lessons or live-streamed lessons (OECD 2020, 145).

How did students fare, under these preparations? As yet, there are not many well-designed, probability-sample-based studies of national causal impact of Covid lockdowns on educational outcomes. Existing studies in China suggest that China was perhaps relatively well-positioned to weather impacts on schooling of quarantines and remote schooling, but students experienced negative educational impacts that tended to be borne differently between privileged and disadvantaged children.

At the primary level, Li et al. (2023) collected and analyzed survey data from representative samples of households and teachers of 4,360 rural and urban primary school students from two prefectures in Henan Province who were forced to stay at home for much of the second semester of the academic year. Results showed that the vast majority of students — 87 percent of rural and 92 percent of urban school students — participated in distance education and most had interactions with teachers (Li et al. 2023, 62, 67). If representative of the larger experience in China, the authors write, results suggest that China "was able to provide a larger share of its K12 student population with the opportunity to learn than much of the rest of the world, even when compared to some high-income nations" (Li et al. 2023, 67).

At the same time, the study highlighted the challenges of children and families not served, as well as the kinds of learning inequalities documented elsewhere around the world (Li et al. 2023, 67):

> Approximately one out of eight rural students and one out of 20 urban students did not receive any distance education at all, and two out of 10 rural students and one out of 10 urban students had no interaction with their teachers. If we use these results to extrapolate opportunities to learn on a national scale ... this means that about 22 million rural and 10 million urban students (32 million total) did not receive distance education during the Covid crisis, while about 33 million rural and 8 million urban students (41 million total) had no interaction with their teachers. Although we cannot fully generalize our findings in these two prefectures of Henan to the rest of China, it would be surprising if other prefectures did not face major problems similar to those found here.

The study showed that the prevalence of smart phones across China was both boon and bane. Widespread availability meant that, perhaps more than in other countries, students depended on smartphones for digital learning in a way that promoted connection to teachers. At the same time, phones were likely to be less conducive to effective study than tablets or computers. Close to three-fourths of students in rural schools used smartphones for distance education, while only about one-fourth of students in urban schools did (Li et al. 2023, 63). Urban students were much more likely to have access to large devices such as computers and tablets. Affected cohorts learned significantly less than the previous cohort of corresponding-grade students (Li et al. 2023, 64). Finally, the estimated economic burden of income loss on parents was substantial: the authors estimate that it was equivalent to about 6 months of the average per capita income of rural residents and about 3.5 months of per capita income among urban parents (Li et al. 2023, 66).

Another study focused on middle schools in Shaanxi Province and used administrative data on a sample of 7,202 students' test scores before and after school shutdowns together with online survey data on students' family background (Liao, Ma, and Xue 2022). Findings showed that middle school students with more highly educated parents experienced an increase in relative test rankings after the shutdown period. This advantage accruing to children of more educated parents occurred via parents' engagement in their children's homeschooling, parents' mitigating the negative impacts of internet addiction on students, and parents' substituting for teachers who were unable to teach well online.

A third study analyzed academic examination scores for students at a high school in Eastern China between January and July 2020 (Ma, Zhang, and Hong 2022). Results showed that academic achievement of students declined during the closure and reopening of the school due to the Covid pandemic, and that the impact was disequalizing — the impact widened gaps between rural and urban students (Ma, Zhang, and Hong 2022, 15). In short, while China may have been relatively well-positioned to weather school closures compared to many places, a story of disproportionate impacts on marginalized children to those seen elsewhere emerged.

3.2.4 EdTech and AI

Experiences with Covid lockdowns underscored the urgency of an existing policy priority: developing digital infrastructure for schools (Australian Embassy in Beijing and Department of Education of Australia 2021).[21] In 2017, the State Council had released a development plan on the use of AI that promoted education in AI-related subjects in primary and middle schools, but also capitalizing on the potential of AI for "smart schools" or "smart education" (Australian Embassy in Beijing and Department of Education of Australia 2021; State Council 2017). The 2017 document promoted "smart education" — using intelligent technology to accelerate the reform of talent training models and teaching methods and build a new educational system that includes intelligent learning and interactive learning; to develop learner-centered educational environments, intelligent campuses, and online platforms; to promote the applications of artificial intelligence in teaching, evaluation, management; and to support opportunities for lifelong education (State Council 2017).

A report by the Center for Security and Emerging Technology indicates that China's government is " ... using its centralized authority to mandate AI education in its high school curricula and for AI companies to partner with schools ... to train students" (Peterson, Goode, and Gehlhaus 2021a, 1). The report describes the high school curriculum as follows (Peterson, Goode, and Gehlhaus 2021a, 11):

> At the high school level, the MOE in January 2018 revised its national education requirements to officially include AI, Internet of Things, and big data processing in its information technology curricula (Ministry of Education of China 2017). The revision requires high school students enrolled in the fall of 2018 and beyond to take AI coursework in a compulsory information technology course (AI Era (新智元) 2021). The coursework goals include data encoding techniques; collecting, analyzing, and visualizing data; and learning and using a programming language to design simple algorithms (AI Era (新智元) 2021).

The report notes that Chinese tech giants such as Baidu are also helping to introduce AI to vocational secondary schools (Peterson, Goode, and Gehlhaus 2021a, 12). More broadly, the significant investment being made in EdTech in China was underscored in a recent report by the International Trade Administration (2022, 6–7):

> In the past five years, China has enjoyed rapid growth in the use of education technology (EdTech) and online learning, both in the private and public sectors. The driving forces include favorable government policies, abundant venture capital, increased consumption, fast-growing mobile Internet penetration, and the fact that

21. A recent report by the International Trade Administration made this observation (International Trade Administration 2022):

> The long-term impact of Covid on education is expected to lead to an increase in spending on digital infrastructure and new digital models utilizing the new tools available in digital education.

the Chinese people attach great importance to education. Since 2015, China has been leading the global investment in EdTech. In 2020, China invested a record-high $10 billion in EdTech (Education Intelligence Unit 2021). From 2010 through the end of Q1 2021, China invested nearly twice the amount of the U.S., six times that of India, and ten times that of Europe, according to Holon IQ.

3.2.5 Evidence about quality

National quality monitoring. In 2015, the Ministry of Education initiated a national assessment plan designed to monitor basic education quality (OECD 2020, 139). In service of this task, a Basic Education Quality Monitoring Center was established at Beijing Normal University, under the supervision of the Ministry of Education (Yin 2021). As mandated by the Education Steering Committee under the State Council, the Center was tasked with monitoring "the performance of primary school students in academic, art and sports subjects, with a view to assessing the progress of compulsory education, particularly the implementation of curricula standards and policies across the country, and informing policy-making to improve the quality of education" (Ministry of Education of China 2018; Yin 2021). Indicators were based on national curriculum standards, with a focus on measuring specific "knowledge and skills acquisition, learning processes and methods, emotional attitudes and values, scientific reasoning and problem-solving abilities" (Ministry of Education of China 2018). The approach covered "student development, from moral, intellectual, physical, social, to aesthetic progress," along with key factors that have a potential impact on the quality of education, including "course teaching, teacher support, school management, and resource allocation" (Ministry of Education of China 2018). The monitoring project involved thousands of stakeholders "from frontline educational administrators, researchers, schoolmasters and teachers, to experts in the fields of curriculum design, teaching theory, educational measurement and evaluation, and education policy and management" (Ministry of Education of China 2018). Consistent with China's efforts to capitalize on the promise of technology, "IT and AI solutions were fully utilized to upgrade monitoring approaches" (Ministry of Education of China 2018).

The first China Compulsory Education Quality Oversight Report was released in 2018 (Ministry of Education of China 2018; Yin 2021). A press release highlighted select findings from the initial report, which covered the period of 2015-2017. The press release highlighted areas of strength in the system, but also highlighted as priority areas for improvement 1) overemphasis on academic achievement, 2) a lack of emphasis on art education and sports, 3) a lack of opportunities for students to develop practical and hands-on skills, including opportunities to carry out experiments and develop critical thinking skills in science classes, and 4) heavy homework loads.

International benchmarking. The OECD conducts an assessment known as the Programme for International Student Assessment (PISA) every three years, in 79 countries among with 600,000 students (Amstrong 2019). The assessment tests the skills and knowledge of 15 year-old students in science, reading and mathematics, along with collaborative problem solving and financial literacy (Amstrong 2019). China's scores for the most recent round are based on students in Beijing,

Shanghai, Jiangsu, and Zhejiang.[22] These places are among the wealthiest provinces of China — they rank 1, 2, 3 and 6, respectively, in provincial per capita GDP (Statistics of China 2022). At the same time, the level of income of these regions is well below the OECD average (Amstrong 2019), and, though estimates are hard to come by, one study suggests that that these areas are characterized by extremely high levels of income inequality (Bhattacharya, Palacio-Torralba, and Li 2018). Much discussion has emerged around the fact that the regions selected for inclusion in PISA are among China's wealthier and more developed areas, and that this and other issues might exert an upward influence on test scores compared to what would be observed in a national sample (Loveless 2013, 2014, 2019; Xu and Wu 2022).

With these points of context in mind, students in these four province-level jurisdictions outperformed peers in other high-performing countries in mathematics, science and reading by what the OECD characterizes as "a large margin" (OECD 2020, 15). Additionally, the OECD reports that educational systems in these jurisdictions have a lower share of low-performing students and a higher share of high-performing students when compared to other high-performing education systems (OECD 2020, 15).[23]

National benchmarking is not possible due to lack of available data. The strong performance on PISA tests just described must be weighed against evidence of a less sanguine nature about educational performance in rural areas put forward by economist Scott Rozelle and his colleagues, perhaps most notably in the recent book *Invisible China* (Rozelle and Hell 2020). A significant concern is that poverty-related stressors on families and associated early health and nutrition problems may impede children's capacity to fully engage in education, particularly in China's competitive educational system.[24]

Relevant to the question of international benchmarking, Gao et al. (2021) collected data from a sample of 23,143 rural primary school students across three provinces in different regions of China —– northwest, southwest, and southeast — and compared this data to student reading achievement data in different countries and regions from the Progress in International Reading Literacy Study (PIRLS) tests in 2011. Results showed that sample students China ranked last in reading skills among a sample of students from the other 44 countries/regions (Gao et al. 2021). While PISA and PIRLS are not the same test, the very poor performance in early reading in these rural areas may appear difficult to reconcile with the very positive PISA outcomes in more developed areas of China. However, this disconnect is less surprising in light of research that has shown that structural factors such as location play a large role in determining educational performance in China (Lyu, Li, and Xie 2019).

In short, absent national data for global benchmarking, it is difficult to characterize overall quality of performance. On one hand, evidence shows that student performance in *some provinces and jurisdictions* on international tests is among the strongest in the world. At the same time, research

22. Jiangsu and Zhejiang are neighboring provinces to Shanghai

23. For example, the percentage of low performers in all subjects (1.1 %, rank 76/76 in 2018) and the percentage of low performers in at least one subject (6 %, rank 76/76 in 2018) were among the lowest among PISA countries (OECD 2023).

24. Highlights are summarized in a recent Center for Strategic and International Studies report (Mazzocco 2022).

also indicates that more marginalized groups of children in China face significant headwinds to reaching those levels of performance.

3.3 Tertiary education

3.3.1 Recent developments

The turn of the 21st century in China saw dramatic expansions in higher education, and with policies that, in targeting elite institutions to compete at the international level, significantly increased horizontal stratification within the higher educational system.[25] In 1999, the central government resolved to substantially increase higher education spaces. The rationales for this shift included a number of educational goals, but reportedly, the most immediate catalyst was economic: increasing tuition-paying students would stimulate consumption after the Asian financial crisis of 1997 (Wang and Liu 2011).[26] The goal was achieved in dramatic fashion. As Li, Whalley, and Xing (2014, 568) report, 1999 was a historic year in the development of China's higher education, with the number of new college students experiencing its greatest increase since 1978, and tuition fees ramping up significantly (regarding tuition, see Yang (2006), as cited in Li, Whalley, and Xing (2014, 568); tuition jumped from increased from 800 RMB per person per year to 5000 RMB per person per year on average.)

Reflecting aggressive higher education expansion policies, the number of students enrolled in degree programs at all kinds of public institutions of tertiary education in China[27] tripled from 3.82 million students in 1990 to 12.29 million in 2000; grew to 33.25 million students by 2010, and reached 44.3 million by 2021 (Ministry of Education of China 2022b). These numbers represent substantial increases in overall access. As a crude indicator of overall access, the gross enrollment ratio grew from 3.4% in 1990 to 12.5% in 2000 to 26.5% in 2010 to 57.8% in 2021 (Ministry of Education of China 2022c).

In 2021, public colleges and universities in China numbered 2,756, including 1,238 bachelor's degree granting universities and 1,518 higher vocational colleges (National Bureau of Statistics of China and Ministry of Education of China 2022e, 2022f; Textor 2022b). There were 764 non-governmental colleges and universities, 256 adult higher education institutes, and 21 other institutions (National Bureau of Statistics of China and Ministry of Education of China 2022e). The majority of enrollments were in public universities, but the private sector is not trivial. In 2021, about 8.5 million undergraduates were enrolled at private colleges and universities, compared to about 35 million enrollees in undergraduate programs in public colleges and universities (National Bureau of Statistics of China and Ministry of Education of China 2022c, 2022g). Among the 35 million students in public colleges and universities, 19.1 million were studying in bachelor's degree programs while the

25. For a review of higher education reforms, see (Xiong, Yang, and Shen 2022) and for a brief review of the academic literature on these tensions, see Shen and Hannum (2023).

26. The discussions of expansionary policies and policies to promote quality draw heavily on Shen and Hannum (2023).

27. Tertiary education in China includes universities, providing four-year bachelor, master and doctorate programs, and higher vocational colleges, providing more practically oriented three-year, short-cycle degree programs; it is also possible to obtain degrees at public institutes for adult education and from online and self-learning courses provided by public institutions (Textor 2022d).

other 15.9 million were enrolled in more practically oriented short-cycle degree programs (National Bureau of Statistics of China and Ministry of Education of China 2022g; Textor 2022d). From vocational institutions, students can enter the job market, join the military, or apply for "top up" programs to earn a bachelor's degree (Peterson, Goode, and Gehlhaus 2021b, 8). A State Council press release indicated that China had added nearly 100 vocational colleges between 2015 and 2019 (Xinhua 2021b). Graduate enrollments, while much smaller, have also been increasing steadily, such that by 2021, around 3.33 million students were enrolled in master's and doctoral degree programs at colleges and universities in China (National Bureau of Statistics of China and Ministry of Education of China 2022a; Textor 2022c).

One side of the agenda was expanding access, but the other was to promote quality — to cultivate Chinese universities to become world-class institutions of higher education. Key initiatives included Project 211 (in 1995), Project 985 (in 1998), and the Double First Class (一流, *shuang yi liu)* project (in 2015) (Bodenhorn, Burns, and Palmer 2020; Postiglione 2020). Project 211 provided extra resources to those universities that could show promise in attaining a higher standard in academic and scientific disciplines and develop the human resources needed to support the national strategy for economic and social development (Postiglione 2020). Project 985 focused resources on a smaller number of elite institutions (Yang and Leibold 2020). Zha (2020) observed that the most elite universities were protected from over-expansion, in order to focus on achieving global excellence, while expansions were taking place in the lower tiers of the higher education system. Local institutions—those under provincial and municipal jurisdictions, including newly emerging higher vocational colleges and higher-cost private institutions—absorbed most of the additional enrollments (Zha 2020); see Postiglione (2020) and Zhou (2020) on private institutions in the wake of expansion). Thus, higher education systems during massification became more differentiated and stratified, with institutions in the top, middle, and lower tiers "differing in orientation toward teaching, research (basic, applied, developmental) and service to the communities they serve" (Postiglione, 2020, p. 922).

The later Double First Class Project (一流, *shuang yi liu*) similarly sought to develop a group of elite Chinese universities, but also to offer support for individual university departments to reach world-class standards (Bodenhorn, Burns, and Palmer 2020). In this way, unlike the earlier projects, the Double First Class project supported not only "the already established universities" but also universities "with urgent needs, distinctive features, and new disciplines" (Yang and Leibold 2020, 1142)). Peterson, Goode, and Gehlhaus (2021b, 6) report that the initiative "split universities into two tracks: 42 universities were selected as world-class universities, and split respectively into 36 "Class A" (already close to being world class) and 6 "Class B" (potential to be world-class) universities."[28] Yang and Leibold (2020) report that institutions outside of the traditional elite group have been able to identify areas of excellence to compete for "double first class"status, though a case study of a relatively poorly resourced university in Tibet illustrates some of the distortions, as well as the possibilities, introduced by the need to compete mainly in fields of comparative advantage. In addition, under this plan, 465 disciplines from 140 universities (including the group

28. See lists of universities by class and listed disciplines available at Education and Research Section of the Australian Embassy in Beijing and Department of Education of Australia (2017).

of 42) are also identified as having the potential to become world class (Education and Research Section of the Australian Embassy in Beijing and Department of Education of Australia 2017). Reportedly, the list of 42 universities includes all 39 of the former "985" project universities, along with three additional universities from the former "211" project: Zhengzhou University (Henan), Yunnan University (Yunnan) and Xinjiang University (Xinjiang) (Education and Research Section of the Australian Embassy in Beijing and Department of Education of Australia 2017). In addition, the discipline development list consists primarily of former "985" and "211" project universities, with an additional 25 non "211" project universities that have strengths in particular fields (Education and Research Section of the Australian Embassy in Beijing and Department of Education of Australia 2017).

The Double First-Class initiative has a broader geographical reach than the former "985" and "211" projects, which aligns with the national education development goal of having more balanced and equitable education for all, but the majority of disciplines to be developed are still clustered in major cosmopolitan areas in the eastern region of China (Education and Research Section of the Australian Embassy in Beijing and Department of Education of Australia 2017).[29] Doctoral training is heavily represented among more elite schools. Peterson, Goode, and Gehlhaus (2021b, 9) reports that about 45 percent of Chinese doctoral students graduate from the elite Double First Class (A) universities, while about 80 percent of graduates come from generally elite universities administered by the central government. Institutions including the Chinese Academy of Sciences, the Chinese Academy of Agricultural Sciences, and the Chinese Academy of Social Sciences are first-tier public research universities not supervised by the Ministry of Education that focus on graduate education (Peterson, Goode, and Gehlhaus 2021b, 9). China reportedly added seven new universities to the the list in February of 2022 and introduced a multi-dimensional evaluation mechanism to identify universities with "distinctive characteristics and comprehensive advantages" (Mao 2022; Zou 2022).

Today, the "C9 League" of public institutions represent the most elite tier (Chinadaily.com.cn 2013; Peterson, Goode, and Gehlhaus 2021b; Times Higher Education (THE) 2011). The C9 League, an association established in 2009, consists of Fudan University, Harbin Institute of Technology, Nanjing University, Peking University, Shanghai Jiao Tong University, Tsinghua University, University of Science and Technology of China, Xi'an Jiaotong University, and Zhejiang University (Chinadaily.com.cn 2013; Times Higher Education (THE) 2011). Peterson, Goode, and Gehlhaus (2021b, 6) report that Eight of the C9 are among the 75 tier-one institutions directly supervised and funded by the Ministry of Education, while the ninth—the Harbin Institute of Technology—is a member of a group of universities directly supervised by the Ministry of Industry and Information Technology.

29. Beijing topped the chart with 162 disciplines, followed by Shanghai with 57 and Jiangsu with 43. These three provinces together have more than half of the total disciplines to be developed (Education and Research Section of the Australian Embassy in Beijing and Department of Education of Australia 2017).

3.3.2 Evidence about quality

This section will elide important questions about quality of experience of students, due to lack of empirical evidence, and focus on a narrow definition of quality as reflected in global ranking systems and research capacity, with particular attention to technical research capacity. Two members of the C9 League–Tsinghua University and Peking University, sometimes referred to respectively as the "MIT of China" and the "Harvard of China" — now regularly reach the highest positions in global university rankings. They are ranked 16 and 17, respectively, in the most recent Elsevier/*Times Higher Education* Rankings; 26 and 34 in the most recent Academic Ranking of World Universities (ARWU); and 23 and 39 in the most recent *US News and World Report Global Rankings*)(Elsevier and Times Higher Education 2022; Shanghairanking.com 2022; Textor 2022d; US News and World Report 2022). A news report observed that in the *US News and World Report* global rankings, for the first time, time China outnumbered the U.S. among the 2,000 schools from more than 90 countries that were ranked: 338 Chinese universities made the list, compared to 280 American universities (Han 2022). Han (2022) observed further that while China "surpassed the U.S. by 58 spots, the majority of U.S. universities appear in the top half of the rankings, including 8 of the top 10."

In a 2022 report for the Center for Security and Emerging Technology at Georgetown, Corrigan and Rodriguez (2022, 1) compared performance over time of Chinese and United States universities on the Academic Ranking of World Universities (ARWU, also known as the Shanghai rankings) and the World University Rankings (QS).[30] Between 2010 and 2020, the number of U.S. universities that appeared in the top 500 on at least one global ranking dropped from 160 to 137, while the number that appeared on both rankings fell from 102 to 82 (Corrigan and Rodriguez 2022, 1). In contrast, Corrigan and Rodriguez (2022, 1) report,

> Chinese universities have made significant gains in the global rankings. Between 2010 and 2020, the number of Chinese universities in the top 500 on at least one global ranking more than tripled (from 23 to 71), while the number that appeared on both rankings rose from 9 to 26. Chinese universities have also steadily moved up the rankings over time.

Corrigan and Rodriguez (2022, 1) observe that improvements in Chinese university rankings seem to be driven largely by increases in research productivity, which in turn coincide with a series of state-sponsored higher education initiatives that have sought to improve the quantity and quality of academic research in China. These improvements have made it possible for universities in China to significantly improve research productivity metrics relative to the United States.

30. Corrigan and Rodriguez (2022, 3) provide this background on the sources of the two ranking systems:

> The Academic Ranking of World Universities, also known as the Shanghai Ranking, is published by the Shanghai Ranking Consultancy, a Chinese analysis group that is not publicly affiliated with any government or university. Prior to 2009, the ARWU was published by Shanghai Jiao Tong University. The QS World University Rankings is published by Quacquarelli Symonds, [which is] a higher education analysis group based in the United Kingdom.

Corrigan and Rodriguez (2022, 4) make two points about trends in higher education quality in China, based on analyses of these two ranking systems — that the Chinese university system is improving overall, and the country's best universities are getting even better:

> In 2010, only two Chinese universities — Peking and Tsinghua — appeared in the QS top 100, and none appeared in the ARWU top 100. By 2020, six Chinese universities — Fudan, Peking, Shanghai Jiao Tong, Tsinghua, Zhejiang, and the University of Science and Technology of China — appeared in the top 100 on both rankings ... All but one of the 23 ranked Chinese universities in 2010 had improved their ranking by 2020.

3.3.3 AI in tertiary education

One emerging subject area that is identified by China as a strategic priority is artificial intelligence. A report by the Center for Security and Emerging Technology states that since 2018, 345 universities in China have been approved to offer an AI major, which is now the country's most popular new major, and at least 34 universities have launched their own AI institutes (Peterson, Goode, and Gehlhaus 2021a, 1). Further, China's AI companies are asked to partner with universities — partnerships focus both on training teachers and students (Peterson, Goode, and Gehlhaus 2021a, 20).

In this new strategic priority area, China is excelling in global rankings. Among the top 10 schools ranked by *US News and World Report*, five are in China, with Tsinghua ranked at the top (Han 2022).[31] A *Harvard Business Review* piece reports on research showing that China's global share of research papers in the field of artificial intelligence "vaulted from 4.26% (1,086) in 1997 to 27.68% in 2017 (37,343), surpassing any other country in the world, including the U.S." (Li, Tong, and Xiao 2021, 2). The authors cite China's "decades-long effort in promoting technology and engineering" in providing "a rich supply of high-quality computer scientists and engineers" (Li, Tong, and Xiao 2021, 5). In a data brief prepared for the Center for Security and Emerging Technology, Acharya and Dunn (2022) analyzed a corpus of more than 200 million publications from six academic data sets. The authors draw a similar conclusion on research strength in this area in China. Among other indicators of growing strength, Acharya and Dunn (2022, 1) report,

> Chinese researchers' output of highly cited AI publications is increasingly competitive with the work of their U.S. counterparts. Over the past decade, Chinese researchers have published a growing share of the world's top-5-percent AI publications, rising from half of U.S. output in 2010 to parity in 2019.

Finally, Acharya and Dunn (2022, 1) underscore that collaborative research between scientists in the United States and China has moved this field forward:

31. The best ranked US institution is Carnegie Mellon, at 12 (Han 2022).

> A notable share of both U.S. and Chinese researchers' high-impact AI publications were U.S.-Chinese collaborations. For example, such collaborations accounted for *24 percent of both countries' highly cited AI publications in 2019* (emphasis added).

4 Outlook

Educational reform and improvement loom large in China's national strategic planning efforts. Past decades have seen tremendous improvements in access to schooling, with expansions in pre-primary and tertiary schooling being notable successes in the 21st century. Improving access and retention at the secondary level is a current priority area. Vocational education is an area of intense policy interest, with a focus on growing numbers and improving quality at both the secondary and tertiary levels. At primary and secondary levels, national evidence about quality of schooling that is comparable to other countries is not available, but available evidence for benchmarking suggests a) that children in some of China's regions are doing extremely well in terms of performance; and b) that children in poorer rural regions face significant barriers to achieving that level of performance. At the tertiary level, available evidence suggests that China's educational institutions are on a strong upward trajectory, and that this is particularly the case in some emerging fields of strategic interest.

Some of the challenges facing China's educational policy makers lie outside of the purview of the educational system. The combination of economic faltering in recent years with high levels of economic inequality is likely to translate to family resource inequalities that pose significant equity challenges even to an educational system based on the premise of allocating places based on fair exams. Many of China's students had access to technology and family circumstances to weather Covid lockdowns, but the challenges of lockdowns, as elsewhere, appear to have been borne disproportionately by economically disadvantaged children and families. Fostering equitable access across economic, geographic, and other divides is an important continuing challenge, looking forward. Demographic scarcity in some rural areas continues to pose a challenge to educational provision in such areas. More broadly, population aging and demographic decline intensify pressures on the policy community to correctly identify promising forms of education that will enable economic flourishing for a future, smaller work force operating in a rapidly transforming economy. Finally, the pandemic and lockdowns likely exacerbated mental health distress experienced by students already facing a high degree of competition and pressure in the school system.

Other challenges will include balancing competing priorities identified for the educational system. In particular, cultivating world class institutions and generally positioning students for internationalization and global competition may sit in tension with other stated national priorities — linguistic and cultural preservation and promotion and fostering national unity, Party loyalty, and patriotism. Recent debates about the appropriate role of the English language in China's educational system are one example of these tension between the goal of supporting global competitiveness and the goal of linguistic preservation (see news reports in Chen (2022) and *The Economist* (2022)).[32] Concerns about preserving national identity, curbing Western influences in classrooms, and reinforcing

32. Part of the concern about weight given to English language in exams may relate to an equity issue within China: that poorer rural students have very little chance to compete in this domain with wealthier urban counterparts.

the primacy of the Party are evident, for example, in recent guidelines on permissible textbooks; yet, these guidelines sit alongside significant investments in international student exchange and engagement in the form of China Scholarship Council Fellowships.[33] Finally, looking ahead, geopolitical uncertainties and tensions appear likely to continue to exert a significant dampening effect on academic exchange and collaboration.[34]

33. See guidance on textbooks in Ministry of Education of China (2019); Cheung (2020) offers a summary. For an overview of activities of the China Scholarship Council Programming, see Fedasiuk (2020).

34. See a recent *Nature* commentary on of the perils of geopolitical tensions for scientific innovation in Lau (2022).

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