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China, U.S. Universities and the U.S. Science and Technology Workforce

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I should mention that this talk is based on two fundamental assumptions. One, China is the only nation in the world that can and plans to challenge U.S. economic, military and ideological leadership. The challenge is partly based on it becoming a major scientific and technological power. The second assumption is that the United States must maintain and strengthen its scientific and technological efforts if it is to maintain a leadership position. And notice I say *a* leadership position rather than *the* leadership position.

In October 2017, Dan Golden published a very influential book – influential in Washington, at least – entitled *Spy Schools*. That book alleged significant spying and intellectual property theft at U.S. universities by Chinese graduate students and Chinese collaborators. Golden's book was soon followed by claims by FBI director Christopher Wray. He made similar allegations implying at the time that almost all graduate students from China should be considered what he called "nontraditional collectors." These allegations were followed by a flurry of activity in the legislative and executive branches of our government. It's the potential consequences of that executive and legislative branch activity that I want to discuss today.

Let's take a look at a particular proposal [Protect Our Universities Act of 2019– H.R. 1678]. It requires the Department of Education to establish a task force that will maintain a list of all sensitive research projects funded by the U.S. government and for each project, if there is a student who is a citizen of one of these specified countries, including China, it will require that there be government approval for that student to work on the project. As you'll see, that constitutes a major change in U.S. policy.

Similarly, the Department of Energy put out a memo in December 2018, again, requiring the noting of sensitive research and not allowing DOE National Labs staff to work with Chinese collaborators on such research. Or, it says, "DOE grant, fellowship, and center recipients will be prohibited from using U.S. tax dollars to conduct international research collaborations or support sensitive country foreign nationals in areas identified in the Science and Technology risk matrix." We interpret that to mean that there will be limitations on what students can work on.

I said this constitutes a major break from U.S. policy. The policy was first clarified for real by President Reagan in what's known as NSDD-189. It's a national security decision directive. And that directive says basically, for research preformed in science and engineering, the results of which are openly published, that shall be labeled fundamental research and all other research, either proprietary or government-classified will be classified with no in-between category like "sensitive." Let me read the second paragraph. It's really important:

"It is the policy of this Administration that, to the maximum extent possible, the products of fundamental research remain unrestricted. It is also the policy of this Administration that, where the national security requires control, the mechanism for control of information generated during federally-funded

fundamental research in science, technology and engineering at colleges, universities and laboratories is classification."

Again, a clear delineation: either research is fundamental, openly publishable, or it's classified. This is also contained explicitly in our policy towards deemed export. And let me explain deemed export.

As probably many of you know, the export of certain instruments and devices and machines is controlled by the government and you cannot ship them to certain countries without a license. That's export control. Deemed export control is provision of information about these controlled items to someone who is from another country. Again, there is a fundamental research exclusion. So that material that is openly published or the normal contents of a course does not constitute deemed export, so it's not controlled.

So this concept of fundamental research being outside these control areas is very much a part of the universe of our government. And in turn, Stanford has two policies that are very important, as do almost all, but not all, the major research universities. One is we don't accept classified research. We don't accept any research which has a restriction on publication, since all the research that we do can lead to publication. It fits the definition of fundamental research. Similarly, we will not accept a contract or a grant that limits participation in that research on the basis of religion, of gender, but also on the basis of citizenship or national origin. Those two principles are fundamental to our research policy.

Given all that activity, the basic questions that I want to address today are threefold. Is it wise to limit universities scientific collaboration with Chinese nationals? And if so, how? Is it wise to limit or inhibit U.S. education of Chinese nationals, and if so, how? And how might universities respond to U.S. government restrictions?

There's a new thought coming in that is being asked in Washington and it's being asked legislatively, which is whether it's appropriate to train students in sensitive research like artificial intelligence or quantum computing. Note that in the very asking of that question, they are breaking that clear distinction between fundamental research and classified research, because they're labeling a very broad area, artificial intelligence or quantum computing sensitive. And there are proposals to put limits on the participation of graduate students. Some even link the training of students in the areas who go back to China as intellectual property theft. This really raises fundamental questions about what are the goals of America's research universities.

I think we've taken pride for 70 years, roughly, in our training of students who go around the world and help raise the standard of living of people in other countries. And it's something that we should take pride in. The other thing is, as you get a sense, more of a sense, the very act of limiting Chinese or Iranian or North Korean students in these endeavors may very well limit the effectiveness of academic research in the United States, and therefore weaken the very fields where we want to keep strong.

But let me point out, throughout a large portion of my career, which began in the early 1960s, the United States was the dominant scientific power. It was clear. Europe was building up strength after the Second World War. But you could see it. And you still see it in the proportion of the Nobel Prizes that are awarded to Americans. But we have to come to terms with reality. We are no longer the dominant funder of research. The point I want to make here is there is a lot of research going on around the world. It's high quality research and we hope in our interactions to learn from it. We are no longer the dominant power with the exclusive secrets to maintain.

The expectation is that sometime this year China will surpass us in R&D expenditures. China is on its way to becoming a major world power in science and technology, and any policy we have has to take that into account.

As you might expect, as the rest of the world has gained capability in scientific research, Americans are collaborating more and more with people outside the United States. Every good research is trying to do the very best research that he or she can do. You don't collaborate with people around the world unless you see the opportunity to do something that's beyond what you alone can do. That is to improve your research, improve the possibility that you'll get the next grant or the next Nobel Prize or what have you. That is, the goal is clear. You want to do better research.

With whom do we collaborate? There is no country in the world with whom we collaborate more than China. In the last year where I have statistics, approximately 9 percent of all science and engineering papers published by an American had a Chinese coauthor in China, not someone in the United States. So the scientists are talking with their feet. They are going where the best collaborators are, and the best collaborators as perceived by them are in China more than any other country.

Will restrictions on collaboration slow down progress in the very fields that are important to us? Will restrictions on personnel, graduate students, have the same effect? And also, will we discourage some of our most creative Chinese-born U.S. scientists from working in critical fields? Peter and I went to a few weeks ago, or maybe a month ago, to a meeting called by the Committee of 100 on these issues. And it is clear that our Chinese scientists and engineers are worried. And if they worry to the point where they stop working in these areas, the quality of American science and technology will go down.

The other thing that concerns me is the following. Remember that China is very strong, Europe is very strong. One natural outcome of restrictions on collaboration is that the Chinese will turn to Europe, just as export controls have had a similar effect, and we could see a Chinese-Europe axis being formed with the US excluding itself from it.

Now let me turn to the workforce. You can’t have strong science and technology without having a strong science and technology workforce. The new American Economy Research Fund did a study and what they claimed was that whereas in 2010, there were 5.4 STEM jobs posted for each unemployed STEM worker. By 2016, that number had risen to 13. Think about that. There are 13 job postings in STEM compared to unemployed people. Mind you, that varies by field to field. It's probably less true of biomedical PhDs and more true of engineering PhDs, which is significant.

U.S. News in August of last year had an article: “STEM Workers Shortage at a Crisis Survey shows.” The DOE, in its 2017 annual report, expressed its worry that a lot of its critical workers were retiring and would it be able to replace them given the shortage. So it's a real phenomenon with real potential consequences.

Now let's take a look and see who gets doctorates in the United States. If you look at engineering, in 2015, U.S. citizens and permanent residents got only 45 percent of the doctorates in engineering. 55 percent went to people who are temporary visa holders. Similarly, in mathematics and computer science, the number goes up to about 47 percent. But you see a majority of the people in these two critical areas as well, not quite a majority in the physical and earth sciences, majority of the doctorates are obtained by foreign students. So foreign students represent a critical part of our science and technology workforce.

Where do they come from? 45 percent of those getting PhDs in the STEM areas come from China, which means that they're roughly 25 percent of the U.S. production of PhDs in engineering and computer science. That's a big figure. The only thing close is India, and they're not that close. So when you start to fiddle with graduate education, you're starting to fiddle critically with the U.S. science and technology workforce.

Well, you might say, do they really stay? So let's take a look at that. What do you can see is that between 2005 and 2015, almost 90 percent of those Chinese students getting PhDs in this area stayed in the United States.

If we are to remain *a* leader in science and technology, we have to be aware of what's going on around the world, and the best way to be aware is to collaborate. Someone, a friend of mine, who is very close to high levels in the Department of Defense, told me the following. For years, the Office of Naval Research depended on its five offices situated around the world to keep the Department of Defense aware of what's going on scientifically. Science has gotten so extensively practiced around the world that those five offices can't keep up. The DOD is now depending on its grantees, particularly those who are collaborating around the world, to inform it of what's going on around the world. We need that information. We don't want to be caught by surprise, by something analogous to Sputnik.

Openness. Openness is part of what made of American research universities so great. Ideas flow back and forth around the university, around the country and around the world. And we should stick by NSDD-189, that distinction between what is only classified or fundamental, and resist every effort to label things sensitive, and, in keeping with our own policies, not accept research in which all students cannot participate and all faculty and staff cannot participate. We have to keep this country attractive for Chinese students and postdocs and those who want to remain in the United States. I think openness is an important part of that. The visa process should be the primary process for keeping out those people that we don't want in the United States. It should not be U.S. universities' responsibility to identify them. And also it should be sufficiently efficient so that students can come here on five-year visas, go home for their families' weddings and funerals and marriages, and return to do graduate work.

And finally, we've got to pay attention to our own country. If you look at public support of research – and remember, it's not the Stanfords and Harvards of this world that produce most of our scientists and engineers, it's the public universities – public support of universities has declined and declined and declined. That's had an impact. Tuitions have gone up and up and up. With tuitions going up and up and up, student debt has gone up and up and up. It's much wiser to go into a much more lucrative field than science if you've got a large student debt.

Finally, I was very impressed, Peter and I went to a conference at USD and a woman named Samm Sacks [Cybersecurity Policy and China Digital Economy Fellow, New America] spoke there. She had testified before the House Foreign Affairs Committee on export control. But I think the guidelines that she proposed for export control are equally valid for what you classify and what you label fundamental. To subject something to greater controls, it has to be essential to military technology. The term "essential" should not be interpreted to encompass technology that's simply used or usable. Second, there has to be a scarcity of knowledge about the technology, except among a small group of experts located in the U.S. or like-minded countries. And third, the U.S. is truly ahead of the curve.

I bring up these criteria because it's artificial intelligence and quantum science that's discussed most. And for the most part, they just don't meet those criteria. That's not critical military technology yet, although it may come, some of it may become that. There's not a scarcity of knowledge: China is an equal player to us in this and we're not ahead of the curve. We are in some fields, but they're ahead in other fields, in other fields Europe's ahead. We can't claim dominance at all.

So I hope that those in Washington thinking carefully about sensitive, classified research or classification take these criteria seriously. Thank you.