COLUMBIA TALK

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Good evening. I'd like to talk this evening about present and future US capabilities in science, technology and engineering (ST&E). In particular, I want to explore whether US strength in these areas will be such as to provide the economy and its people with prosperity, in terms of growth and standard of living, and its foreign and security policy with sufficient military and economic capability. The elements of such strength in style include people, structure, funding, and the corresponding educational system.

We can approach this question in terms of competition with other countries, that is to say our relative position, but it's at least as useful to think in terms of a self-comparison. Will per capita GDP grow fast enough to help us solve internal problems? Will US cultural, political, economic and military capability provide the US with the ability to hold the effect of external events to a satisfactory level (which is how I define national security)?

US preeminence at the end of the twentieth century was undergirded, among other elements, by its leadership in science, technology and engineering. It had not always been that way. Until World War II, US weight in world affairs derived largely from the size rather than the sophistication of its economy. It was not the leader in science, technology and engineering; that position was held in Western Europe, by Germany, France and the UK. Things began to change before and especially during World War II. Radar and the atomic bomb were developed in the United States as the first billion-dollar examples of the application of big science and technology to military ends. But the original science had been done in Europe and its application in these specific projects was largely the contribution of immigrants from Europe. Notably, conventional military equipment deployed by Nazi Germany, for example tanks and early jet aircraft, was of better quality than that of the US. As another example, before World War II, American scientists studied in Europe during the 1920s and 1930s, but began to get their own Nobel prizes by 1940.

Following World War II, the US government launched a huge effort to support and grow American science, technology and engineering. New agencies such as the National Institutes of Health, the National Science Foundation and the Atomic Energy Commission, were created. They, along with the Department of Defense, increased effort at civil service laboratories, provided grants and contracts to universities, new non-profits, and the corporate sector, funding what had previously, on a much smaller scale, been the purview of philanthropy and business enterprise.

The US university system, then already as good as any, was pumped up in its education aspect by the GI Bill. On the research and development side, the same government agencies supported pure and applied research in the physical, biological and medical sciences. That produced people, knowledge and intellectual property. The close connections that American research universities forged with government and industry over the next five decades remains unmatched in other countries.

Beginning in the late 1940s and late 1950s national security was the rationale. Early on, defense research and development spun off into the civil sector both jet transports and digital computers. The whole system got a second nudge from Sputnik at the end of the 1950s and this carried through until the end of the Cold War. During the last few decades of the twentieth century the US dominated the Nobel prizes in science. The US was also where leadership in semi-conductors, computers, information technology, microbiology, biotechnology and telecommunications was to be found. Not all of the inventions were turned into innovation (which is not the same thing) in the US; some innovations took place in Japan and in Western Europe. But the US was dominant.

Now globalization, through increasingly free flow across national boundaries of capital, goods and services and people, and fostered by low-cost, high-speed communications, is changing the picture. The availability of increasingly skilled labor in China, India and other parts of Asia at much lower wage rates than exist in the developed world has already moved much manufacturing into those countries. That continues a global trend that goes back 150 years in the US, and longer in the UK -- the migration of very-low income agricultural workers into higher but still low income manufacturing jobs. Now, manufacturing is only in the mid-teens as a percentage of US GDP and probably the low teens in terms of US jobs. Jobs in services, some at the high-income end, some at the low, have replaced the lost manufacturing jobs, just as over a much longer earlier period manufacturing replaced agriculture in the US economy as a source of jobs. And in fact US manufacturing output is still double that of China. But in technology China in hardware and India in software are becoming more competitive and, in science, especially Europe but also Asia compete on equal or near-equal terms with the US.

Will the US be left behind in science, technology and engineering, losing relative economic and strategic position as a result? And will skilled competition at lower compensation rates in science, technology and engineering in the developing countries reduce compensation levels in these areas in the United States? There's little doubt that offshoring to lower-wage sites, where it is possible and economic, can put downward pressure on compensation for similar jobs in the United States. And whether a task can be offshored depends both on the availability of the skill level and on the requirement or lack of it for an on-the-spot presence. Plumbers, truck drivers and nurses are not likely to have their jobs offshored; radiologists and engineers, depending on their skill level, may be more at risk.

Some loss in relative terms of the US lead is almost inevitable. Those who start from near zero learn from leaders, knowledge diffuses and as their per capita GDP increases more effort in developing countries will go to science, technology and engineering. But will the US be overtaken? Will US growth slow, will the standard of living in the US stall, will US military capability become inferior? My answer is no, or at least not necessarily.

In economic terms, the question is whether the US can move its jobs up the value-added scale while lower wage developing countries take on a larger fraction of the existing jobs, at least those that can be offshored. In that connection, much is made of the number of engineers being turned out in developing countries. The recent National Academies report called “Rising Above the Gathering Storm” notes that last year more than 600,000 engineers graduated from institutions of higher education in China and 350,000 in India whereas in the US it was about 70,000. But clearly that can’t be the whole story, because we have heard similar statistics in past decades expressed as threats that seemed, and perhaps were, serious, but fizzled. I’ll come back later to the reasons they fizzled.

I agree that there is a deficiency in the number of scientists and engineers turned out by US universities both at the baccalaureate and at the graduate degree levels. To date, much of that deficiency has been filled by immigration; half the graduate students in science and engineering come from outside the United States and most of them have tended to stay. Recently, legislation and immigration regulations following the attack of September 11, 2001 have made it harder for that flow to continue and I believe it very important that that negative trend be reversed. Moreover, I am in agreement with the general thrust of the recommendations of the National Academies report, some of which I will comment on in a moment.

What is the effect of a disparity in such numbers? Basic science is pushed forward by a few of the best minds. The US seems to me not disadvantaged on that score, because the best scientific minds seem to find their way to science despite the deficiencies of the educational system. A modest rate of growth of government support for basic research, especially targeted at younger investigators as suggested by a National Academies report, will be important in maintaining the US research enterprise, the connection of which to both government and the private sector has been so important in innovation.

In attracting more bright minds below that very top level into science and technology and engineering, where numbers probably do count for more, I see two issues. The first is the competition from other professions – law, consulting, investment banking, all of which pay better. The disparity of reward inhibits some bright minds from becoming scientists and engineers. The market is saying that scientists and engineers are being paid what their value is to their employers. I have my doubts about whether the market is really a free one in these terms; some of the other professions seem to be better able to extract rents above what a truly free market would provide. And the value to society is not identical with the value to the firm. One way to reduce the disparity of reward is to follow scientific and engineering training with employment in other roles; lawyers seem to find lots of other things (often even more lucrative) to do after their legal training. A second way to increase numbers is to improve the quality of teaching in science and mathematics, especially in elementary and middle school, because a youngster who leaves middle school without a sufficient level of competence in mathematics and understanding of science will not be able (even in the unlikely case of being willing) to major in a scientific or technical field at the post secondary level.

In my judgment there is another effect, at least equally important, of the poor quality of elementary and high school teaching in mathematics and science. In a world where important issues depend increasingly on questions of science technology and their interaction with public policy, the general public in the US is unable to make informed judgments on these matters for lack of mathematical and scientific understanding. A public more than half of which believes that the human species was created separately from all the others and (according to one survey) twenty percent of which believes that the sun goes around the earth, and which has no way of thinking about probabilities in any realistic way, is unlikely to be able to resist the junk science (or the junk economics or junk sociology) that is argued on all sides of debates about energy supplies, global warming, nuclear proliferation, stem cell research, ballistic missile defense, and on and on. So I support the recommendations that the report of the National Academies makes for increasing both America's professional talent pool and citizen-level awareness by vastly improving K-12 math and science education, through encouraging scholarships for top students who want to become teachers in science or mathematics. Getting them accepted then as teachers afterwards may not be so easy given the attitudes of school boards and teachers' unions. Another source would be retired military people or retired science and engineering professionals who could help bring knowledge of and interest in science and mathematics to schools where teachers of these subjects with either a knowledge of or passion for these subjects are so hard to find.

Let me come back now to the issue of whether the US and its people are going to be left behind in the global marketplace, and whether American standards of living and national security will suffer in consequence. I noted earlier that we have been through this issue before. From Sputnik through 1970s and into the early 1980s the Soviet Union was seen as posing a major competitive technological threat; it graduated several times as many engineers as the United States. But it clearly was unable to translate those numbers into an industrially competitive system or to reverse the qualitative military advantage held by the US. Why was that? My answer is that innovation, whether industrial, general economic or military, depends on more than technical or individual competence. Those are necessary but not sufficient. Innovation requires also success at the enterprise level and at the overall systems level, that is, the nature of the economic and political system as a whole. The Soviet system, even though it had capable technology and capable people, failed at the enterprise level; its businesses and ministries were dysfunctional. And it failed at the overall systems level; the centrally directed economic and political model was a total failure.

In the 1990s the Japanese also graduated more engineers than the US and they had excellent technology. You may recall the view of the commontariat in the early 1990s that the Cold War was over and that Germany and Japan had won. Japan was about to overtake the United States as the world's leading economy. That didn't happen either. Japanese success was not limited by deficient science and engineering, or by not having capable people. And they succeeded at the enterprise level; at least the large manufacturing firms directed at export did. But at the national political and economic level the Japanese system had (and has) severe limits. So Japan did not take over the world.

Now as the prospectuses say, past performance is no assurance of future returns. China, and possibly India, may well avoid the cultural and political pitfalls that limited the USSR and Japan. In any event, the US faces, in the globalization of which it has been the prime advocate and mover (and considerable beneficiary), several severe challenges. Neither our affluence, nor our influence, nor our security is guaranteed. Success will require substantial attention to improving both our educational system and the research, development and innovation enterprise. Much of that attention will have to come from the government, though America's universities and its technically oriented business will also have to play a leading role. K-12 education is principally a state and local government responsibility. The resulting diversity of approach could become a strength; at the moment it is mostly a complication. And assuring that federal government support does not become the heavy hand of government direction, and that the private sector and the educational institutions work together with government as part of a broader societal effort, will not be easy, especially in a situation in which there are many worthy societal objectives in competition for attention and resources. Politics, and economics, personalities and ethics, are as vital to achieving these ends as science, math, technology and engineering (which itself is a mixture of technology and economics). In dealing with politics, and economics, ethics and personalities, what we learn from studying Thucydides and Machiavelli and Locke is no less central than what we learn about science from the work of Willis Lamb or Eric Kandel. That's why what I learned in Andrew Chiappe's Colloquium class has stayed with me as much as what I learned from Mario Salvadori in his Differential Equations class. But how to apply the lessons of Humanities and Contemporary Civilization courses to modern political and social issues would be the subject of an entirely different talk.