China's Path To Becoming A Knowledge-Based Economy

by Marsha Freeman

The contrast between the collapse of the degenerate, profit- and crime-driven bankrupt trans-Atlantic financial system, and the government-vectored, science- and technology-driven growth of Asian nations, could not be more dramatic than by comparing the United States and China. President Obama's insipid remarks about China's "cheap labor" economy just shows how stupid, or lying, he (and too many other Americans) are. China sees its future economic growth driven by advancements in the leading fields of science and technology. Space exploration and advanced nuclear- and fusion-energy technologies have been leading areas of focus.

While the American System of economics, upon which the world leadership of the United States was based, has been discarded here, it is alive and well in China. If China continues on its present path to becoming what it calls a "knowledge-based economy," where there is a national mission, supported by national investment, and driven by meeting the most challenging aims of mankind, there is little question as to where leadership will be in the near future.

In July 2014, the U.S. National Academy of Sciences published a study titled, "China's rise as a major contributor to science and technology," in its *Proceedings of the National Academy of Sciences.* This follows two earlier reports by the Academy, which asked the questions: Is the United States losing its scientific leadership role? And will this lead to negative economic consequences?[1] The most recent study answers those questions, documenting the accomplishments of China's science and technology enterprise over the past 20 years, in comparison to the stagnation and decline in the U.S.

Hand-wringing in despair, or alternatively, carrying out a vilification campaign and punitive sanctions against China, are hardly winning strategies. Trying to isolate China has only helped encourage closer relationships and joint projects among nations in Asia; increased the urgency and deepened the commitment for the financial integration of the BRICS nations (Brazil, Russia, India, China, and South Africa); and isolated, not China, but the U.S. and the European nations that are clinging to a modern version of rule by a feudal oligarchy.

By almost any indicator, China is moving as quickly as it is able to meet its goal of becoming a knowledge-based economy. The labor-intensive, export-oriented policies of the last three decades are being superceded by advances in science, translated into new technologies, directed to transform the productive workforce of China, through education, and a transformation in the standard of living, and the cultural level, of the population.

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1. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (2007); and *Rising Above the Gathering Storm: Rapidly Approaching Category 5* (2010); National Academy of Sciences, National Academy of Engineering, and Institute of Medicine; National Academy Press, Washington, D.C.

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The scientists and engineers who will create China's future are the young people, now in colleges and universities, who will create a "knowledge-based economy." This university student showed off his design for a Moon rover at an international lunar exploration conference in 2006 in Beijing, just as China was starting its lunar exploration program.

China's path relies upon 1) educating succeeding generations of scientists and engineers; 2) repatriating the talent that left China and went overseas in the past decades, along with encouraging contributions from foreign experts; 3) planning and executing the great projects, such as in fusion and space exploration, which in the past played a seminal role in building a scientific capability in the U.S., and which are inspiring to young people and the general population; and, 4) facilitating the integration of scientific and technological breakthroughs into the physical economy of the nation.

Educating New Generations of Scientists

At the end of the 1970s, the Chinese leadership was faced with the task of rebuilding what had been destroyed during the Cultural Revolution—in education, culture, history, and science. One legacy of the Cultural Revolution was the absolute decline in the number of natural scientists from 1982 to 2000, through the loss of a decade of the training of new scientific talent, and the retirement of scientists who had been educated before the Cultural Revolution.

To refocus national priorities, and organize the process of creating a pathway to a knowledge-based economy, in 1977, Deng Xiaoping announced that the State Science and Technology Commission would be restored, and a 1982 government document declared that economic development should rely on science and technology. Project 863 (March 1986) outlined seven areas that would be the focus of a national program to upgrade science and technology: automation, biotechnology, lasers, new materials, space, information technology, and energy. Project 211, in 1995, was promulgated to upgrade research capabilities in 100 universities.

In March 1997, Project 973 was initiated to focus on basic research; and in 1998, the more ambitious Project 985 was declared, to build world-class universities. President Jiang Zemin, in a speech for the 100th anniversary of Peking University, proposed that "several world-class universities and a number of universities with worldwide reputation" be established in China. The Ministry of Education selected Peking and Tsinghua Universities as its first targets, investing $300 million in each of them, between 1999 and 2001. The project was eventually expanded to include 39 universities. These initiatives have produced dramatic results.

In 1982, only 0.8% of Chinese young adults between the ages of 25 and 29 had a post-secondary-school education. Through a concerted three-decade effort to expand public education, that figure rose to 20.6% in 2010. In 1998, the government decided to dramatically expand China's higher education system, focused largely in the science and engineering fields, and *doubled* the number of institutions offering post-secondary courses, to 2,263. In addition, the existing institutions were restructured, upgraded, and enlarged.

As a result, today, China is the world leader in bachelor's degrees granted in science and engineering, with 1.1 million in 2010, or more than four times the U.S. number. In 1993, China's number of science and engineering doctoral degrees was only 10% that of the U.S. In 2010, China *exceeded* the number of doctoral degrees granted in the U.S. by 18%.

But considering that the population of China is more than three times that of the United States, it is not that surprising that China is producing a larger number of scientists and engineers than the United States. Therefore, as the study published by the Academy points out, it is the proportion of science and engineering graduates to the total number of graduates, and future trends, that are indicative. In 2010, 44% of the undergraduate students in China majored in science and engineering disciplines, as compared to 16% in the U.S. And that gap has been increasing since 1998.

This educational emphasis, along with incentives for talented young people to enter science and engineering fields, has produced concrete results in terms of the manpower available to the Chinese economy.

In 1982, China's scientist/engineer labor force was 1.2 million, about 80% of the U.S. figure of 1.5 million. By 2010, that number had grown to 3.2 million in China, with the U.S. at 4.3 million. Although the growth rates were similar for both countries, comparing engineers alone, there were 2.4 million in China, and 1.4 million in the U.S. in 2010, indicative of China's determination to translate its scientific advances into applications in its economy.

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During the Shenzhou-10 mission in June 2013, astronaut Wang Yaping conducted science experiments inside the Tiangong laboratory, which were watched by an estimated 30 million students. Economic incentives are offered to students who choose science and technology fields of study, but inspiration from great projects create the drive to excel.

Repatriation of Scientific Talent

There is a large diaspora of Chinese-origin scientists, the Academy report states, with significant numbers in the United States. China has had a very focused effort to encourage them to return. A report released on Aug. 7 by the China and Globalization and Social Sciences Academic Press in China, reports that overseas Chinese constitute the largest expatriate community in the world, with an estimated 2.4 million people in the U.S. alone, more than 800,000 in Europe, and so on. Although the report claims that China should be doing a better job of overseas recruitment, it states that many of the overseas professionals identify themselves as Chinese who see themselves able to help the development of China.

To address the repatriation of this indigenous talent, the Changjiang Scholars Program began in 1998, offering incentives for short-term visits by overseas Chinese scholars. The Thousand Talent Program, or the Recruitment Program of Global Experts, was launched in 2008, with the goal of, over a decade, recruiting up to 2,000 senior-level scientists residing in foreign research institutions. Aided by the global financial crisis, the Academy of Sciences article states, by April 2012, 2,263 scientists had returned to work in China. Some of the returning scientists were so prominent that the U.S. science community was taken by surprise.

This is an approach that could be well utilized by the Russian Federation, as well. Large numbers of the former Soviet Union's scientists emigrated in the early 1990s, to find opportunities abroad, as federal support for scientific programs and institutions all but disappeared. That talent could significantly upgrade major projects underway, such as the reform of Russia's aerospace sector.

There is another fruitful potential source of young science and engineering talent that can augment China's human resources. In 2012, there were 4,217 Chinese doctoral engineering and science students studying in the United States. Chinese citizens represent 28% of the total foreign graduate student body in the U.S., and more than 8% of all of the doctoral science and engineering students in U.S. colleges and universities. Although in the past, many of these young graduates did not return to China, it is no longer assured that the majority of these newly minted scientists and engineers will stay in the U.S.

Chinese-born scientists are not the only ones leaving the U.S. for China. Forbes magazine reported last October that one-fifth of American scientists had been planning to move overseas since the previous Spring, due to the possibility of a U.S. government shutdown. One newspaper article quoted a professor from George

Mason University saying that his laboratory could be shut down, unless he moved it to China.

In the fusion program, there is close cooperation between U.S. and Chinese scientists, in which the U.S. has the theoretical knowledge and decades of experience, and the Chinese have a growing program that is advancing into new areas. American fusion scientists, who have been unable to build new experimental facilities, and are, in fact, faced with the shutdown of the shrunken fusion program that exists today, have teamed up with leading research institutions in China for joint experiments, and the sharing of scientific results. If the situation does not radically change, American fusion scientists may find themselves packing their bags and moving to China.

The unilateral U.S. prohibition on cooperation with China in space exploration does nothing either to protect America's disappearing leadership in space, or to hamper China's ambitious programs. As the U.S. has lowered its sights in its exploration goals, our traditional partners in exploration, in Europe and Russia, are turning to China for cooperation in the most challenging future projects.

If there is not a radical change in U.S. policy, it can be expected that more of America's most talented engineering and scientific cadre will go where they can make contributions in science and technology.

The 'Apollo' Effect

While governments can encourage young people to pursue scientific studies and careers through the availability of world-class research facilities, economic incentives, and higher social status, it is the challenge to accomplish great projects that have not been attempted before, that inspires young people.

Throughout the decade of the 1960s, the challenge of President Kennedy's goal of landing a man on the Moon created more scientists and engineers than any other U.S. program, before or since. Ask most leading space scientists today what inspired them to undertake a career in Mars exploration, lunar development, manned space missions, or any number of other fields, and they will say it was the Apollo program.

The legacy of the Apollo program is most profoundly the creative talent that was developed, not only for the space program, but which fanned out in to every leading field of science and technology, from nuclear energy to advanced manufacturing, to new materials, medicine, and biology.

China's two leading scientific programs, in space exploration and fusion, are attracting the talent that will create the breakthroughs of the next two decades. The Chang'e lunar exploration program, carried out with maximal public exposure and involvement (such as the contest to name the lunar rover) has created widespread recognition, enthusiasm, and pride in China's accomplishments. Similarly, the science lessons taught from orbit by astronaut Wang Yaping a year ago aboard China's Tiangong-1 orbiting module, captured the attention and imagination of more than 30 million Chinese students.

China's accomplishments have also increased its confidence to take on a leadership role in international fora, focused largely in cooperation with Asia's less-developed nations. The First China-South Asian Countries Science and Technology Ministers Meeting convened in Kunming on June 6. Participating were ministers and senior officials from Afghanistan, Pakistan, Sri Lanka, Bangladesh, Maldives, Nepal, and India. Discussions included setting up joint state-level laboratories and research centers, encouraging young scientists to work in China, technology-transfer programs, and cooperation in specific areas, such as agricultural technology.

To engage a more diverse group of nations, China has proposed that there be established a BRICS framework for Science, Technology, and Innovation. A broad array of potential projects has been suggested for the initiative, which includes applications of space technology, as well as in astronomy.

The Apollo program demonstrated the leadership of the United States in an endeavor that captured the imagination of the entire world. As it has gained confidence, China has dramatically opened up its space exploration program to widespread public exposure and a concerted education campaign. This will inspire not only China's youthful population, but those of many countries that are aspiring to become spacefaring nations.

From Science to the Economy

The pursuit of scientific excellence and advancement in China is not seen as an academic exercise but as a necessary public good. Unlike the Soviet Union, which was not very successful in transferring groundbreaking technology from its civilian space and military programs to the civilian economy, China is deliberately placing science and technology at the center of its planned transformation to a knowledge-based economy.

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A knowledge-based economy will only be successful if the educational and cultural level of the nation's entire population is uplifted. Exhibits, such as the Shenzhou-1 space capsule, at the Beijing Science and Technology Museum, shown here, capture the imagination of visitors of all ages.

In 1982, reversing the ideology of the Cultural Revolution, the Chinese government declared that "Economic development should rely on science and technology." In 1986, the National Natural Science Foundation of China was established, modeled on the National Science Foundation in the U.S. The 863 Program, or State High-Tech Development Plan, followed, to stimulate the growth of high-technology enterprises.

In the late 1980s, China began establishing high-tech zones, with the goal of shifting the mode of economic growth. After two decades of development, these targeted development zones encompass 78,000 enterprises with 14 million employees. They are contributing more than 10% of China's gross domestic product. Strategically important high-tech industries represent 37% of the total number of registered enterprises, employing 7 million people.

The Beijing Zhongguancun innovation demonstration zone, approved for construction in 2009, illustrates China's approach to applying scientific advancements to economic development. There are 20,000 enterprises in the zone, with industry clusters which include communications, satellite applications, biomedicine, energy conservation, and rail transportation. But what creates the conditions for the industrial park to become a leader in innovation, is that it encompasses 41 higher education institutions, including the prestigious Peking and Tsinghua Universities, 206 national research institutes, 67 laboratories, 55 national engineering research centers, 29 university science parks, and 34 overseas student pioneer parks. More than 6,000 enterprises have been started by 20,000 repatriated Chinese from overseas. The high-tech zones function to translate the scientific breakthroughs in universities and research laboratories into new economic platforms for the nation.

In March 2013, the Ministry of Science and Technology issued an action plan for the high-tech zones, which includes expanding pilot projects that have been successful, particularly near Beijing, to other areas. The plan emphasizes that an important goal is to accelerate the commercialization of achievements in research. The focus is on the technological upgrading of traditional industries in regional economies, and creating entirely new industries based on technological advancements.

'Benefiting the Entire Human Race'

One might expect that an article published by the U.S. Academy of Sciences would take the parochial, supposedly "American" point of view, that competition from China in fields of science and engineering is a "threat" to this country. On the contrary, the conclusion of the report states: "In the past three decades, China has become a major contributor to science and technology. When science in China and other fast-developing countries improves, it greatly expands the scale of science and thus speeds up scientific discoveries, benefiting the entire human race."

The Apollo 11 astronauts left a plaque on the Moon, stating that they "came in peace for all mankind." This approach is echoed by the Chinese in their great projects, such as lunar exploration, which officials have also acknowledged is "for the benefit of all mankind." It is the approach that must come to replace that of the dying Western economies immediately.