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Collaborative Advantage

The days of U.S. technological domination are over. The nation must learn to thrive through working with others.

NEW HORIZONS FOR A FLAT WORLD

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MICHAEL SCHULTHEIS, *Convexity Involutus 01*, Acrylic on canvas, 36 x 72 inches, 2004.

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Almost daily, news reports feature multinational companies—many based in the United States—that are establishing technology development facilities in China, India, and other emerging economies. General Electric, General Motors, IBM, Intel, Microsoft, Motorola—the list grows steadily longer. And these new facilities no longer focus on low-level technologies to meet Third World conditions. They are doing the cutting-edge research once done only in the United States, Japan, and Europe. Moreover, the multinationals are being joined by new firms, such as Huawei, Lenovo, and Wipro, from the emerging economies. This current globalization of technology development is, we believe, qualitatively different from globalization of the past. But the implications of the differences have not sunk in with key U.S. decisionmakers in government and industry.

It is not that the new globalization has gone unnoticed. Many observers are concerned that the United States is beginning to fall into a vicious cycle of disinvestment in and weakening of its innovation systems. As U.S. firms move their engineering and R&D activities offshore, they may be disinvesting not just in their own facilities but also in colleges and regions of the country that now form critical innovation clusters. These forces may combine to dissolve the bonds that form the basis of U.S. innovation leadership.

A variety of policies have been proposed to protect and restore the preeminent position of U.S. technology. Some of these proposals are most concerned with building up U.S. science and technology (S&T) human resources by strengthening the nation's education system from kindergarten through high school; encouraging more U.S. students to study engineering and science, specifically inducing more women and minorities to pursue science and technology careers; and easing visa restrictions that form barriers to talented foreigners who want to enter U.S. universities and industries. Other proposals include measures to outbid other countries as they offer benefits to attract R&D activities. Still others call for funneling public funds into the

THE UNITED STATES NEEDS TO AGGRESSIVELY LOOK FOR PARTNERSHIP OPPORTUNITIES—MUTUAL-GAIN SITUATIONS—AROUND THE GLOBE.

development of technology. Some observers, for example, believe that the technological strength of U.S. firms would be improved by the government's greatly increasing its support of basic research.

Our studies of engineering development centers in multinational home countries and in emerging economies lead us to a concern that many U.S. policymakers and corporate strategists, like the proverbial generals preparing to fight the previous war, are failing to recognize what is distinctive about today's emerging global economy. Indeed, in some cases they are pinning their hopes on strategies that were not notably successful in past battles. Although our research suggests several trends that may be problematic for the United States, we also see strong possibilities that the nation can benefit by developing "mutual gain" policies for technology development. Doing so requires a fundamental change in global strategy. The United States should move away from an almost certainly futile attempt to maintain dominance and toward an approach in which leadership comes from developing and brokering mutual gains among equal partners. Such "collaborative advantage," as we call it, comes not from self-sufficiency or maintaining a monopoly on advanced technology, but from being a valued collaborator at various levels in the international system of technology development.

First, however, it is necessary to understand the trends that could lead to a vicious cycle of disinvestment in U.S. S&T capabilities and, most important, how these trends differ from previous challenges to the U.S. system.

Fighting the last war

Half a century ago, the United States was shocked by the ability of the Soviet Union to break the U.S. nuclear monopoly and then to beat the United States in the race to launch a space satellite. Americans were deluged with reports that Soviet children were receiving a far better education in S&T than were U.S. children and that the USSR graduated several times as many engineers each year as did the United States. Worse, the USSR appeared to be targeting its technological resources toward global domination. Twenty years later, Americans were further shaken by the rapid advance of Japanese (and then Korean) firms in industries ranging from steelmaking and auto production to semiconductors. It was widely pointed out that Japan graduated far more engineers per capita than did the United States. As the Japanese seemed on a relentless march to dominance in industry after industry, pundits in the United States commented that whereas the brightest young U.S. students studied law or finance, the brightest Japanese studied engineering. Books were written about Japanese government policies that targeted certain industries, enabling them to gain comparative advantage in key technologies. Some observers advocated the establishment of a U.S. Ministry of International Trade and Industry on the model of Japan's. As the United States lost its technological edge, many feared that it would also lose its ability to maintain its global power and high standard of living.

The military threat from the Soviet Union was real, but it diminished as a result of weaknesses in the Communist economic and technological systems. The economic threat from East Asia also quickly diminished. To be sure, the United States lost hundreds of thousands of jobs beginning in the 1980s as multinationals moved production to low-cost sites offshore and as new multinationals from Japan and Korea took growing shares of global markets. But even though that shift was painful for certain U.S. companies and for workers who lost their jobs, the U.S. economy as a whole grew along with the growth in world trade, and much of the new U.S. workforce moved into higher value–added activities.

The United States was not saved from either of these threats because it improved its educational system to surpass those of other countries or because it managed to produce more engineers than other countries. The United States had other strengths. It attracted large numbers of talented foreigners to its universities and businesses. It provided the world's most fertile environment for fostering new business ventures. Its institutions were flexible, enabling human and other resources to be constantly redeployed to more efficient uses.

At the end of the past century, the United States was spending far more on R&D than Japan and nearly twice as much as Germany, France, and the United Kingdom combined.

The globalization challenging U.S. firms in the 1970s and 1980s was different from the globalization in the more immediate postwar era. In the 1950s and 1960s, U.S. firms had taken simple, often obsolete technology offshore to make further profits in markets that were less demanding than those at home. That era of globalization was dominated by U.S. (and some European) firms. Wages could be far higher in the United States than elsewhere because the U.S. workforce, backed by more capital and superior technology, was far more productive. Firms did not need to worry much about foreign competition. Moreover, trade restrictions protected the privileged situation enjoyed by U.S. companies and workers.

Beginning in the late 1960s, however, it was becoming clear that the world was moving to a second generation of postwar globalization. One of the most notable facets of this new wave was the emergence of large numbers of non-Western firms to positions of global strength in automobiles, consumer electronics, machine tools, steelmaking, and other industries. U.S. firms often were blindsided by the emergence of these new competitors, and many domestic firms at first refused to take them seriously. It was thought that the Japanese could make only lower grades of steel, unsophisticated cars, or cheap transistor radios, but that U.S. firms would hold on to the higher value–added, top ends of these markets. In part because of this arrogance, U.S. firms sought "windfall" income by actually selling technology to firms that would soon be their competitors. Meanwhile, capital and technology were becoming more mobile, and Japan and a few other countries became major sources of innovation and global finance. The momentum of the East Asian firms was further increased as these firms enjoyed the advantage of home and nearby markets that were growing faster than those in the United States and Europe.

When the U.S. technology system found itself challenged by the Japanese and others, many firms sought to reassert their dominance by lobbying for the protection of their home markets and by using their overwhelming strengths in basic technology and their access to capital to maintain competitiveness. Still, many leading U.S. firms, such as RCA, Zenith, and most of the integrated steel producers, failed. But others, such as GE and Motorola, thrived in the new environment. Those that succeeded were relatively quick to give up industries where there was little chance to compete against their new rivals, quick to find new opportunities outside the United States, and often quick to find new partners.

The globalization of today represents another quantum leap. We believe it is different enough to characterize it as "third-generation globalization." It stems from the emergence of a new trade environment in the 1990s that has vastly reduced barriers to the flow of goods, services, technology, and capital. The move to a new environment was accelerated by the development and diffusion of new communications, information, and work-sharing technologies over the past decade.

Strategies that may have served U.S. firms in the second-generation globalization will not work in the third-generation world. The new emerging economies are an order of magnitude larger than those that emerged a generation ago, and they are today's growth markets. Nor does the United States, despite its undeniable strengths, enjoy global dominance across the range of cutting-edge technologies. Moreover, U.S. multinationals are weakening their national identities, becoming citizens of the countries in which they do business and providing no favors to their country of origin. This means that the goal advocated by some U.S. policymakers of having the United States regain its position of leadership in all key technologies is simply not feasible, nor is it clear how the United States would retain that advantage when its firms are only loosely tied to the country.

We believe that there are opportunities as well as challenges in the third-generation world. Our research, however, does suggest some other reasons to be concerned about certain developments that are now taking place.

Current trends could lead to an unnecessary weakening of one of the foundations of U.S. economic strength: the country's national and regional innovation systems. Four factors have surfaced in our research that, in combination, may undermine the innovation capacity of U.S.-based firms and technology-savvy regions of the country.

The bandwagon syndrome. As U.S. multinationals join the bandwagon of offshore technology development, they often seem to go beyond what makes economic sense. Top management at many firms are coming to believe that they have to move offshore in order to look as though they are aggressively cutting cost—even if the offshoring does not actually result in demonstrated savings. None of the companies that we studied conducted systematic cost/benefit analyses before moving technology development activities offshore.

The snowball effect. The more that U.S. multinationals move activities offshore, the more sense it makes to offshore more activities. When asked what activities will always have to be done in the United States, the engineering managers we interviewed could not give consistent and convincing answers. One R&D manager said he found it difficult to engage in long-term planning because he was no longer sure what capabilities remained at his company after recent waves of technology outsourcing.

The loss of positive externalities. Some multinationals are finding that if their technology is developed offshore, then it makes more sense to invest in offshore universities than in domestic universities. Support for summer internships, cooperative programs, and other efforts at U.S. universities becomes less attractive. As one study participant noted, "Why contribute to colleges from which we no longer recruit?"

The rapid rise of competing innovation systems. Regional competence centers or innovation clusters in the United States grew haphazardly in response to local market stimuli. China, India, and other countries are much more explicitly strategic in creating competence and innovation centers. Although markets have worked well for the U.S. centers, it is essential that these centers have a better sense of where their overseas rivals are moving, what comparative advantages provide viable bases for local development, and how to strengthen them.

As these developments have unfolded, many U.S. firms or their domestic sites are now running the risk of losing their capabilities to innovate. At best, they may be able to hold on to only a diminishing advantage in brand-name value and recognition.

Another factor that is proving important is the declining ability of the United States to attract the world's best S&T talent. As an open society and the world's leading innovator, the United States was long able to depend heavily on the inflow of human capital. Although the market impact of high-skill immigration has been widely debated, it is clear that this inflow eased the pressure to increase the domestic S&T workforce through either educational or market inducements.

The United States was highly dependent on foreign-born scientists and engineers in 1990, and its growing need for S&T human resources in the 1990s was met largely through immigration. An issue widely discussed and analyzed in depth by the National Science Foundation (NSF), among others, is that the inflow of immigrant S&T personnel began to slow down beginning in the late 1990s. Coupled with the longer downward trend of U.S. students entering S&T fields and careers, this raises concerns about whether the United States will have adequate personnel to maintain its technological leadership.

The changes in migration patterns go beyond just the availability of a science and engineering workforce. Immigrants have been an important source of technology entrepreneurship, particularly in information technology. Less noted is the potentially quite large loss of technology entrepreneurship and innovation with the decline in the number of emerging-economy S&T people who might start businesses, and the return of growing numbers of successful U.S.-based entrepreneurs to their home countries to take advantage of opportunities there.

It seems clear from our interviews, however, that efforts to solve the perceived U.S. technology problem by emphasizing policies to induce more U.S. students to major in engineering are no more likely to succeed than did similar efforts made in response to the Japanese challenge. None of the engineering managers we interviewed mentioned a shortage of new graduates in engineering as a problem. Indeed, some managers said they would not recommend that their own children go into engineering, since they did not see it as a career with a bright future. Several said they were not allowed to increase "head count" in the United States at all; if they wanted to add engineers, then they had to do it offshore. Increasing the number of engineers coming into the system might do no more than raise the unemployment rates of engineers. In fact, if increasing the short-term supply of scientist and engineers leads to increased unemployment and stagnant wages, it will further signal to students that this is not a good career choice.

To be sure, there are good reasons to increase the representation of women and minorities in U.S. S&T education programs. It also is desirable to increase the technical sophistication of U.S. students more broadly, and to make it attractive for those who are so inclined to go into the S&T professions. But "throwing more scientists and engineers at the problem" should not be sought as a strategy to regain a U.S. monopoly over most cutting-edge technologies. It would be a mistake to try to replicate the technological advantages enjoyed by other countries in these areas. The United States cannot match the Chinese or Indians in numbers of new engineering graduates.

Rather, the United States needs to develop new strengths for the new generation of globalization. With U.S. and other multinational firms globalizing their innovation work, emerging economies developing their education systems and culling the most talented young people from their huge populations, and communication technologies enabling the free and fast flow of information, it is hard to imagine the United States being able to regain its former position as global technology hegemon.

What the United States needs now is to find its place in a rapidly developing global innovation system. In many cases, strong companies are succeeding through the integration of technologies developed around the world, with firms such as GE, Boeing, and Motorola managing project teams working together from sites in the United States, India, China, and other countries. It is unclear, however, the extent to which it would benefit the United States to subsidize the technology development efforts of companies headquartered in the United States. For example, it is Toyota, not GM, that is building new auto plants in the United States; it is China, not the United States, that owns, builds, and now designs what were IBM-branded personal computers; and it is countries ranging from Finland to Taiwan that are doing leading-edge electronics development. The one area overwhelmingly dominated by the United States, packaged software development, employs less than one half of 1% of the workforce and is unlikely to have a large direct impact on the economy, although use of the software may contribute signifi-

MICHAEL SCHULTHEIS, *Curvatures 01 02*, Acrylic on canvas (diptych), 48 x 102 inches, 2004.

cantly to productivity increases in other industries.

As a country, the United States is strong in motivating university researchers to start new enterprises, from biotechnology to other areas across the technology spectrum. The United States is not as strong when it comes to projects where brute force applications of large numbers of low-wage engineers are required. Nor is the United States as strong in developing technologies for markets very different from its own. Competitive strategies from the past will not change this situation. No amount of science and engineering expansion will restore U.S. technology autarchy. Instead, a new approach—collaborative technology advantage—is needed to develop a vibrant S&T economy in the United States.

Policies for strength

We believe that the government, universities, and other major players in the U.S. innovation system need to work toward three fundamental major goals:

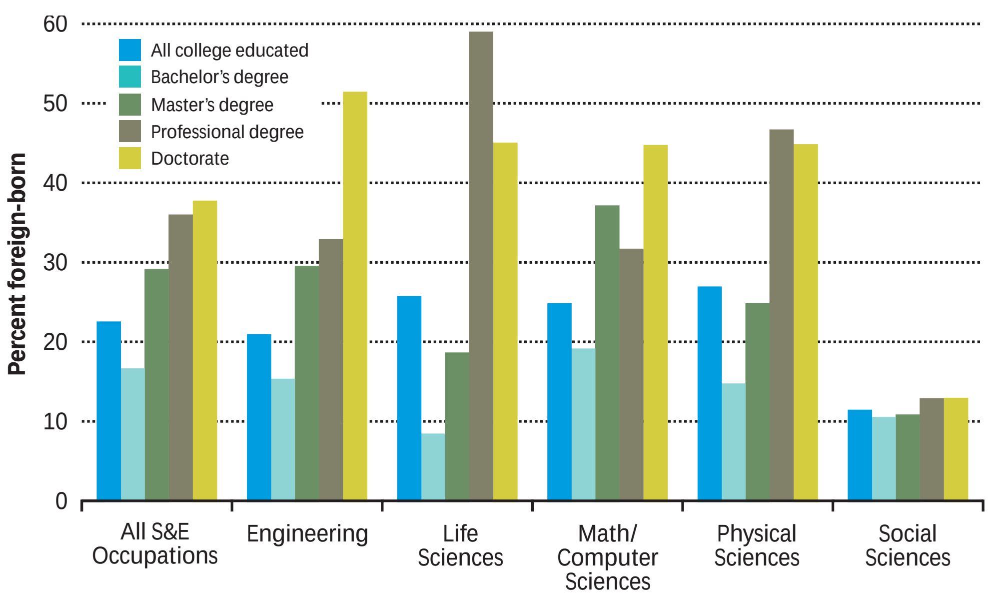
First, the United States should develop national strategies that are less focused on competitive, or even comparative, advantage in the traditional meaning of these terms, and are more focused on collaborative advantage. It is tempting to think of technology in neomercantilist terms. National security, both militarily and economically, can depend on a country's ability to be the first to come out with new technologies. In the 1980s, it was widely believed that Japan and other East Asian economies were using industrial policies to create comparative advantage in high-tech industries in the belief that these industries provided unusually high levels of spillover benefits. U.S. policymakers were advised to counter these moves by investing heavily in high technology, restricting imports of high technology, and promoting joint technology development programs by U.S. firms.

To be sure, it makes sense for U.S. policy to ensure that technology development activities are not attracted away by foreign government policies, where the foreign sites do not have legitimate comparative advantages. It also makes sense to make sure that the United States retains strength in technologies that truly are strategic. An important, but difficult, task is finding ways to develop policies that strengthen U.S. S&T capabilities when market pressures are leading firms to disinvest in their U.S. capacity, including their university collaborations.

To start, the nation needs to counter the bandwagon and snowball effects that are driving the outsourcing of technology in potentially harmful ways. To do this, it will be necessary to develop new tools to assess the costs and benefits of the outsourcing of technology development, particularly tools that more comprehensively account for the costs. There also is a need to develop a better understanding of what technology development activities are most efficiently colocated, so that the United States does not end up destroying its own areas of comparative advantage. NSF and other funding agencies could sponsor such studies.

But then the United States needs to aggressively look for partnership opportunities—mutual-gain situations—around the globe. National government funding agencies, such as

Foreign-Born S&E Workers in the United States, 2000



Source: U.S. Census Bureau.

REGIONS HOSTING OR DEVELOPING TECHNOLOGY COMPETENCY CENTERS NEED TO LOOK CLOSELY AT THE INTERNATIONAL COMPETITION. THEY NEED TO IDENTIFY NICHES THAT EXIST OR CAN BE DEVELOPED IN THE CONTEXT OF A GLOBAL INNOVATION SYSTEM.

NSF, and regional governments can support projects that work toward these aims. Designers of tax policies at all levels also can redirect policies in these directions. Some of these mutual-gain situations will involve the creation of technologies that unequivocally address global needs to minimize environmental damage or reduce demands on diminishing resources.

Regions hosting or developing technology competency centers need to look closely at the international competition. They need to identify niches that exist or can be developed in the context of a global innovation system. Existing artificial barriers for certain industries and technologies will continue to fall at a rapid pace as the world continues its path to globalization. Alliance may be possible between U.S. centers of technology competence and those in other countries.

We believe that one area in which the United States enjoys comparative advantage is its patent system. To a large degree, the U.S. patent office serves as the patent office for the world. Foreign firms want access to the U.S. market, so they must disclose their technology by filing for patents in the United States. It is essential that the United States preserve (and perhaps extend) this advantage.

As a second goal, the United States needs to help create a world based on the free flow of S&T brainpower rather than a futile attempt to monopolize the global S&T workforce. The United States can further develop its advantage as an immigrant-friendly society and become the key node of new networks of brain circulation. Importantly, the United States needs to redesign its immigration policies with the long view in mind. New U.S. policies should focus on the broad goal of maximizing the innovation and productivity benefits of the global movement of S&T workers and students, rather than the shortsighted aim of importing low-cost S&T workers as a substitute for developing the U.S. domestic workforce. This implies that an alternative to the current types of visas that cover foreign-born students and S&T workers—such as the H-1b visa—needs to be developed. Promoting the global circulation of students and workers, while not undermining the incentives for U.S. students and workers, will create human capital flows that support collaborative advantage. The goal should be to make it easier for talented foreign S&T people to come, study, work, and start businesses in the United States, and also make it easier for foreign members of U.S. engineering teams to come to the United States to confer with their teammates. Visas shouldn't be used to have permanent workers train their replacements or to distort market mechanisms that provide incentives for long-term S&T workforce development.

Immigration policies that support global circulation would allow easy short-term entry of three to eight months for collaboration with U.S.-based scientists and engineers. Facilitating cross-border projects actually helps retain that work here; our research finds that when projects stumble because of collaboration difficulties, the impulse is to move the entire project offshore. When U.S. S&T workers have more opportunities to work with foreign S&T workers, they broaden their perspective and better understand global technology requirements. A new type of short-term, easy-to-obtain visa for this purpose would strengthen the U.S. collaborative advantage while not undermining the incentives for U.S. students to pursue S&T careers and continuing to attract immigrants who want to become part of the permanent U.S. workforce.

Finally, in working toward the first two goals, the United States needs to develop an S&T education system that teaches collaborative competencies rather than just technical knowledge and skills. U.S. universities must restructure their S&T curricula to better meet the needs of the new global innovation system. This may include providing more course work on systems integration, entrepreneurship, managing global technology teams, and understanding how cross-cultural differences influence technology development. Our findings suggest that it is not the technical education but the cross-boundary skills that are most needed (working across disciplinary, organizational, cultural, and time/distance boundaries). Universities must build a less parochial, more international focus into their curricula. Both the implicit and explicit pedagogical frameworks should support an international perspective on S&T—for example, looking at foreign approaches to science and engineering—and should promote the collaborative advantage perspective that recognizes the new global S&T order. Specific things that could be done include developing exchange programs and providing more course work on cross-cultural management, and encouraging firms to become involved in this effort through cooperative ventures, internships, and other programs.

Our research suggests that the new engineering requirements, like the old, should build on a strong foundation of science and mathematics. But now they go much further. Communication across disciplinary, organizational, and cultural boundaries is the hallmark of the new global engineer. Integrative technologies require collaboration among scientific disciplines, between science and engineering, and across the natural and social sciences. They also require collaboration across organizations as innovation emanates from small to large firms and from vendors to original equipment manufacturers. And obviously they require collaboration across cultures as global collaboration becomes the norm. These requirements mandate a new approach not only to education but to selecting future engineers: colleges need to recognize that the talent required for the new global engineer falls outside their traditional student profiles. Managers increasingly report that although they want technically competent engineers, the qualities most valued are these other attributes.

Education policy must reflect the new engineering paradigm. It must structure science and engineering education in ways that encourage students to pursue the new approaches to engineering and science. Indeed, we believe that the new approaches will make careers in science and engineering more exciting and attractive to U.S. students. Information technology, for example, is famous for innovation that comes from people educated in a wide range of fields working across disciplines. The education system needs to better understand the new engineering requirements rather than attempt to shore up approaches from a previous era. This is a challenge that goes beyond providing more and better science and math education. It does, of course, require strengthening basic education for the weakest students and schools, but it also requires combining the best of education pedagogy with an understanding of the requirements of the "new" scientist and engineer.

Leadership in developing a global science, technology, and management curriculum may also attract more international S&T students to U.S. universities. Other desirable changes may include collaborative agreements with universities in emerging economies that enable U.S. students to be sent there for part of their education, thus helping to promote the overall move to brain circulation. Government support might be needed to make such programs economically viable for U.S. universities—for example, by making up some of the tuition differences between U.S. and foreign universities.

We believe that progress toward these goals will lead to a future where U.S. residents can more fully benefit from the creativity of S&T people from other countries, where the U.S. is still a leader in global innovation, and where a stronger U.S. system is revitalized by accelerated flows of ideas from around the world.

Recommended reading

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Kent H. Hughes, *Building the Next American Century: The Past and Future of American Economic Competitiveness* (Baltimore, MD: The Johns Hopkins Press, 2005)

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