# A Leadership Forum

# on

# International Graduate Students in Science and Engineering and International Scientists and Engineers

# A National Need and a National Opportunity

**Convened by**

**University of California, Irvine**
**The Merage Foundations**

Arnold and Mabel Beckman Center
National Academy of Sciences and Engineering

University of California, Irvine

October 16 – 17, 2005

MERAGE FOUNDATION
FOR THE
AMERICAN DREAM

National Advisory Board

December 9, 2005

Dear Colleagues:

We are pleased to send you the summary report of the proceedings of the Forum concerning International Graduate Students in Science and Engineering and International Scientists and Engineers: A National Need and A National Opportunity. The Forum was convened by the University of California, Irvine and the Merage Foundations on the evening of October 16th and during the day on October 17th. It was attended by nearly 50 outstanding government, business, university and non profit group leaders.

The sessions focused on issues related to the application and enrollment of international graduate students in U.S. graduate programs of science and engineering and the ability of international scientists and engineers to live and work in the U.S. During the Forum, participants expressed concerns over the post 9/11 trends suggesting that applications from international students are trending downward and that many outstanding international scientists and engineers are finding it increasingly difficult to find permanent residency and employment in the U.S. Clearly, a long term decline in applications and subsequent enrollments of international graduate students in science and engineering and a similar decline in the numbers of international scientists and engineers immigrating to the U.S. would negatively affect U.S. national security interests and U.S. global economic competitiveness.

Participants heard from key university, business, non-profit group and government officials during the Forum. Most of the time, however, was consumed by substantive, intense discussion. Participants were able to reach a remarkable degree of consensus on a set of strategic recommendations to government, businesses, universities and non-profit groups. They are included in the report and summarized in its Executive Summary.

We want to thank each of the participants for attending the Forum. Their contributions to the Forum were significant. We would like to express our gratitude to the Forum's speakers and panelists. They helped provoke meaningful discussions among participants.

Many Forum participants reviewed early drafts of the report. Their comments were helpful in capturing the Forum's important themes. We want to thank Marshall Kaplan for an excellent job in facilitating the Forum's dialogue and in preparing the final summary report of the Forum.

We would welcome your comments on the report. Please send them directly to Marshall Kaplan at Mkaplan@meragefoundations.com. We intend to use this report in concert with Forum participants and involved national organizations to help stimulate a national dialogue concerning the Forum's recommendations.

Sincerely Yours,

Paul Merage
President of Merage Foundations

Dr. Michael Gottfredson
Provost and Executive Vice Chancellor for
Academic Affairs
University of California, Irvine, California

# International Graduate Students in Science and Engineering and International Scientists and Engineers: A National Need and a National Opportunity

## A Leadership Forum

**Convened by the University of California, Irvine and the Merage Foundations**

**October 16 - 17, 2005**

**The University of California, Irvine**

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**Executive Vice Chancellor & Provost, Academic Affairs, University of California, Irvine**

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**A Leadership Forum**

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## University of California, Irvine
## The Merage Foundations

### Executive Summary

Nearly fifty government, business, university and non-profit group leaders met on October 16 and 17, 2005 in the Arnold and Mabel Beckman Center of the National Academy of Sciences and Engineering in Irvine, California. The Forum was hosted by the University of California, Irvine and the Merage Foundations. Its agenda focused on national concerns regarding the decline in applications from international graduate students to U.S. science and engineering graduate programs and the restrictions impeding the migration of international scientists and engineers to the U.S to secure employment opportunities. Participants agreed to examine the dimensions of both and their impact on the U.S. economy and U.S. security. Participants also agreed to discuss and, if they reached consensus, to recommend policy options to encourage increased numbers of international graduate science and engineering students to study and stay in the U.S. after graduation and increased numbers of international scientists and engineers to live and work in the U.S.

During the course of the Forum, participants agreed that the recent upturn in enrollments of first time international graduate students was a good omen. But the fact that the percentage increase was very small and was juxtaposed with a continuing decline in applications did not suggest a permanent turnaround in graduate school science and engineering enrollments and a return to pre-9/11 numbers. Indeed, total enrollments of international graduate students in key science and engineering disciplines continue to reflect percentage declines.

Both business and university leaders participating in the Forum expressed concern that a long-term downward trend in international graduate student applications and enrollments in U.S. graduate programs of science and engineering would threaten America's economic competitiveness and preeminence in technology. Business participants indicated that national boundaries should not impede hiring the best scientists and engineers. They expressed concern that, despite recent Department of State improvements, complex visa processes still detoured many fine graduate students from U.S. universities. For example, current regulations require would-be graduate students to provide evidence of intent to return home after graduation in order to secure visas. According to the businesspersons at the Forum, the intent to return home requirements sends exactly the wrong message. The U.S. should encourage graduating students with advanced degrees in science and engineering to live and work in the U.S.

University officials at the Forum provided similar messages. They worried about the recent downturn in applications and enrollments. They expressed fear that if it continued university research and development initiatives would suffer significantly. Foreign students contribute much to the diversity of their campuses and the richness of the classroom experience for all students. They provided a tangible source of research innovation, particularly with respect to patent awards.

Participants across sectors agreed that national security after 9/11 deserved real attention and priority. However, they emphasized that initiatives to secure national and economic security priorities were often two sides of the same policy coin and that success regarding one without success regarding the other would leave the U.S. in a vulnerable position with respect to its safety and its quality of life. The U.S. must calibrate the balance between national security and economic security in a deliberate manner and find the right balance between secrecy and openness. Increasingly effective technology should permit the U.S. to meet security objectives while at the same time removing unnecessary restrictions impeding international graduate students from studying science and engineering in the U.S. as well as international scientists and engineers from living and working in the U.S.

The participants at Forum agreed on the following recommendations:

Government

1. The Administration and Congress should ask an independent group of respected organizations to develop a strategic paper defining the relationship of international graduate students and international scientists and engineers who desire to migrate and work in the U.S. to national security and economic security. Once finished, the paper should be given wide distribution and used to frame reform of visa and security policies.

2. Congress should amend section 214b. International student applicants for visas, particularly students wishing to study in U.S. university graduate science and engineering programs, should be exempted from the present requirement that they prove or show an intent to return. Similarly, the Administration and Congress should provide international graduate students who graduate from U.S. university science and engineering programs streamlined access to a green card. Congress should allow employers to pay an extra premium processing fee to speed up relevant green card reviews and to allow international graduate students to secure an H-1 B visas (and repetitive renewals) until they secure green cards.

3. The Department of State should grant Visas for international students that allow for multiple access to the U.S.

4. The Congress should expand the number of employment-based immigrant Visas or green cards. It should increase the caps and quotas associated with H-1B Visas and permanent status or green cards for high-tech professionals essential to U.S. economic security. Spouses and children should not be counted against quotas for employment-based immigrant scientists and engineers.

5. The Administration should mandate involvement of scientists and engineers from relevant federal agencies in policy making discussions concerning visa and work restrictions on international students and scientists and engineers.

6. The Administration working with business as well as university leaders should develop a coherent coordinated marketing plan to encourage international students, scientists and engineers to come to the U.S.

7. The Department of State should require more transparency in consular decisions concerning Visas. Students and professionals should be informed of the status of their respective applications and, unless security considerations are involved, the reasons for visa refusals. The State Department should consider providing preliminary and tentative approval of visas to potential students preceding their applications to American universities.

8. The Administration and Congress should provide international graduate student assistance through programs of the U.S. Agency for International Development, particularly for students desiring to study science and engineering in America.

9. The Administration and Congress should provide increased predictable support for basic science and engineering research.

10. The Administration and Congress should commit to develop, support and carry out policies and programs to improve science and mathematics curriculum and teaching in public schools. Both should engage universities, businesses, non profit groups, school districts and community organizations in a sustained effort to strengthen the educational choices of children in science and mathematics.

Universities and Business

1. Universities should develop better data and analyses concerning their international student populations. They should be better able to track students from admission to jobs. They should improve their capacity to evaluate and describe the benefits and costs of foreign students on specific university priorities such as graduate curriculum and research, patent awards, and faculty and student recruitment. Universities have a strong case to make concerning the negative impact that a sustained downward trend in foreign student enrollments would have on their quality and on their ability to respond to and strengthen U.S. economic and quality of life objectives. They need to make this case in a loud and clear manner.

2. Universities and businesses should develop a unique and continuous partnership. The partnership should: establish a joint marketing initiative to encourage international graduate students desiring to study science and engineering; create a national pool of money for scholarships and fellowships for international graduate students enrolling in university science and engineering programs in the U.S.; increase leadership and citizen understanding of the link between expanded access to the U.S. of foreign graduate students who desire to study science and engineering in American universities and national and economic security objectives.

Next Steps

The co-hosts of the Forum, the University of California, Irvine and the Merage Foundations, agreed to prepare and distribute this summary report to government, business, non-profit group and university leaders across the nation. The participants agreed to work with the University and the Merage Foundations to use the report to help foster a national dialogue and consensus strategies to convert the U.S. commitment to create a more encouraging environment for international graduate students in science and engineering and international scientists and engineers to reality.

# International Graduate Students in Science and Engineering and International Scientists and Engineers: A National Need and a National Opportunity

## A Leadership Forum

**Convened by the University of California, Irvine and the Merage Foundations**

**Arnold and Mabel Beckman Center of the National Academy of Sciences and Engineering at the University of California, Irvine**

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# International Graduate Students in Science and Engineering and International Scientists and Engineers: A National Need and a National Opportunity

## A Leadership Forum
### Convened by the University of California, Irvine and the Merage Foundations

Nearly fifty government, business, university and nonprofit leaders met on October 16 and 17, 2005[1] in the Arnold and Mabel Beckman Center of the National Academy of Sciences and Engineering in Irvine, California. The Forum was hosted by the University of California, Irvine (UCI) and the Merage Foundations. Its agenda reflected national concerns over the decline in applications from international graduate students to U.S. graduate programs in science and engineering and the restrictions limiting the capacity of the U.S. to encourage international scientists and engineers to secure employment opportunities in the U.S. Forum participants agreed to discuss the dimensions of both concerns and their respective impact on the U.S. economy and U.S. national security. Participants also agreed to discuss and, if they reached consensus, to define policy options that would attract increased numbers of international graduate science and engineering students to study in the U.S. and increased numbers of international scientists and engineers to live and work in the U.S.

Both hosts, the University of California, Irvine and the Merage Foundations, indicated support for former Secretary of State Colin Powell's comment that "international students and scholars benefit from engagement with our society and academic institutions and we benefit enormously from their interaction with our society as they help our citizens develop understanding and knowledge that enriches our lives, increases international cooperation, enhances our national security and improves our economic competitiveness."[2]

### Framing the Forum

[1] The Forum began October 16th in the evening and concluded at the end of the day October 17th.
[2] Statement from Colin L. Powell, Secretary of State, International Education Week, November 15-19, 2004. Washington, DC. Posted October 15, 2004. http://exchanges.state.gove/iew/statements/powell.htm.

Dr. Michael Gottfredson, Executive Vice Chancellor of UCI and Paul Merage, Chairman of Board of the Falcon Investment Group and the President of the Merage Foundations, welcomed the participants on Sunday evening, October 16. Subsequently, Paul Merage, UCI's Chancellor Michael Drake, Jack Rosenthal, President of the New York Times Foundation, and Acting Undersecretary of the U.S. Department of Homeland Security Randy Beardsworth made opening comments. They helped frame the Forum's important agenda.[3]

Paul Merage, President of the Merage Foundations and former CEO of Chef America, indicated that America must be able to compete in an increasingly global economy, an economy premised on the delivery of innovative leadership, management, services, and products. The capacity of American universities to continue to attract outstanding international graduate students in science and engineering is essential to America's sustained capacity to grow its economy and continue its global economic leadership. The apparent short term decline in foreign graduate students wishing to study science and engineering in America's graduate schools is disquieting. If it is real and if it continues, the decline will have a major negative impact on America's capacity to play a leadership role in driving this century's global innovation economy. With more countries actively recruiting international graduate students and researchers in science and engineering, America cannot rest on its past scientific laurels. Obstacles preventing international students, scientists and engineers from coming to America are counterproductive to both our national security and economic interests.

Dr. Michael Drake, Chancellor of the University of California, Irvine, noted that the numbers of international students applying to and enrolling in U.S. graduate school degree programs since 9/11 are down. It is important to determine the extent of the decline and whether it is simply a short term post 9/11 phenomenon or a long term problem. A significant decrease in graduate enrollments caused by overly bureaucratic visa policies, an environment perceived as hostile to foreigners, a lack of scholarship and fellowship funds, and a decline in research and development funding will have a pervasive negative effect on the quality of U.S. university graduate programs in science and engineering. It will severely affect the ability of U.S. universities to maintain their global preeminence and their important research and development functions. It will impede the capacity of universities to contribute scientific and technical innovations to America's economy and to help the nation sustain its economic vigor and leadership.

According to Jack Rosenthal, President of the New York Times Foundation and former Pulitzer Prize Winning Editor of the New York Times, America has for most of its history provided a welcoming destination site for immigrants. Immigrants have been essential to the vitality and development of America. There are various ways to measure international student contributions starting with the most obvious money. Foreign students spend about $13 billion a year in this country. As noted by Allan Goodman, President of the Institute for International Education, international education is now America's fifth largest service sector export.

Further, direct dollars do not compare to the larger economic and social impact. 9/11 brought a sudden change. Security needs transformed visa policies. The U.S. open door image turned into an image of a cold, Catch-22 bureaucracy. This new image endures even though the government has responded to the security problem with increasing sophistication.

America now recognizes that visa regulations are not the only reason for the change in foreign student enrollments.

[3] Marshall Kaplan, Executive Director of the Merage Foundations, facilitated the discussions and authored this summary report of the proceedings based on the comments of participants and notes taken by several observers.

U.S. universities face competition from other excellent universities in many countries. China is one of them. It is committed to creating some of the best universities in the world. The United Kingdom has put a billboard outside the U.S. Consulate in Chennai that reads, "Study in the U.K.! Visas in two days." Germany, IDP, Australia, Russia, and France are all recruiting foreign students in science and engineering.

The U.S is not well regarded in other nations. The Pew Global Attitudes Project survey of sixteen nations showed that anti-American feelings shot up as a result of the Iraq war. While the negative figures have abated slightly, they remain punitively high. The government, its institutions of higher learning, and the private sector must improve recruiting efforts; we must make foreign students welcome.

Security has a larger dimension than just safety. According to Rosenthal, William Wulf, President of the National Academy of Engineering, recently told a U.S. House of Representatives Subcommittee that protecting Americans from threats must obviously be a high priority. But real security will be achieved only with a proper balance of openness and secrecy. With selected, thoughtful changes to U.S. policies, we can achieve both goals, making our homeland safer and our economy stronger.

Rosenthal concluded by saying that the motto for the Forum's deliberations should be, the Statue of Liberty has long lifted a lamp of welcome. Let it now also raise a lamp of learning.

Randy Beardsworth, Acting Undersecretary of the U.S. Department of Home Land Security[4] called attention to the need to grant priority to the nation's security while trying to find ways to reach out to and attract foreign students and scientists to America. He acknowledged that visa regulations, data collection and surveillance procedures were strengthened after 9/11. Some foreign students and scientists, perhaps many, were discouraged from coming to America to study or work. However, the U.S. Department of State and the Department of Homeland Security have taken steps to make the visa system simpler and more responsive to the needs of foreign students, scientists and engineers. Rapid advances in technology for risk assessment and maintaining surveillance will lend confidence to security personnel and over time permit them to consider more flexible and welcoming visa approaches. The Department of Homeland Security is open to dialogue concerning visa and surveillance reforms with regard to students, scientists and engineers.

America must find efficient and equitable ways to balance national security objectives with objectives related to the country's need to recruit increased numbers of international students to America's universities and top international scientists and engineers to its universities, research centers and businesses.

## The Numbers and the Impact

Dr. Frank Bean, Co-Director of the Center for Research on Immigration, Population, and Public Policy at UCI, indicated that the number and percentage of international science and engineering graduate students have grown in the U.S. for many decades. Their share of the total number of students increased from near 24 percent in the early 1980s to nearly 35 percent in 2002. The share of international postdoctoral students grew from approximately 37 percent in 1982 to 58 percent in 2002. Clearly, international students and scholars have become an increasingly larger and more integral part of science and engineering programs.[5]

[4] Acting Undersecretary Beardsworth will soon take over an important new position within the Department of Homeland Security.
[5] Dr. Frank Bean noted that information collected on the visa status of graduate students did not distinguish first time from continuing students until 2001, resulting in only a very short time series of relevant data. Dr. Bean suggests that it is difficult to disaggregate permanent residents from naturalized citizens because National Science Foundation's statistical reports group these together with native citizens.
A recent paper by the American Institute of Physics (AIP Pub. Number R-440, September 2005) also suggests data and analytical problems concerning development of fine line estimates of the relationship between visas, applications, admissions, and enrollment. For example according to the paper, "fluctuations in applications data are a very poor predictor of actual changes in

Enrollments of first time international graduate science and engineering students were not tracked until 2001. Between 2001 and 2003, enrollments dropped by 4,605 students or a decline of 13.5 percent. Because the declines did not occur among U.S. permanent resident/students, it is reasonable to assign some part of the cause for the decline to post 9/11 visa regulations.

Declines in international graduate students in science and engineering continued through at least 2004. Overall, international graduate student applications were down nearly 30 percent in 2003-2004, and over 35 percent for international graduate students in science and engineering. The downward trend was less in life sciences and physical sciences; 24 percent and 26 percent respectively. Interestingly, smaller declines occurred in enrollments. For example, enrollments declined among engineering and life science students by 8 percent and 10 percent respectively. They were up by 6 percent in the physical sciences [6]

It is not clear whether the post 9/11 decline reflects a long term trend. While the initial numbers for the 2005 academic year seem better, they have not recovered to 2002 levels despite a more efficient visa process and the extension of student visas from one to four years,

Dr. Bean expressed concern that the fall off in international graduate student applications and enrollments may be in part related to the downward trend in research and development expenditures in many science and engineering fields relative to the size of the overall economy. He noted that the U.S. ranks no better than seventh[7] in the world in the priority granted investment in research and development (R and D). The U.S. share of global R and D has gone down from nearly 40 percent to just over 36 percent since the mid 1990s. He suggested that the relative decline may even be more dramatic with respect to basic research, given the fact that long term government spending for science and engineering related research appears to be trending downward or at best is holding steady except for funding from the National Institutes of Health.[8] Should funds for basic research in science and engineering become a casualty of budget deficits, the result could be fewer foreign graduate and post doctoral students in science and engineering programs.[9]

According to Dr. Debra Stewart, President of the Council of Graduate Schools, first-time enrollment of international graduate students rose by 1 percent in the fall of 2005. However, applications for fall were down another 5 percent.[10] Further, total enrollment of international students is down by 6% in engineering,

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enrollment …. This reflects the fact that the two quantities are quite independent of each other, with only loose feedback looping" (p. 6). Further, the paper implies that visa denials or delays sometimes blur what is happening and may not be linked strongly to applications in any one year or to enrollments. Some foreign students have permanent resident visas or temporary visas … and are already in the country.

[6] Dr. Bean and his colleague Dr. Susan Brown indicate that because most students apply to and may be admitted by more than one school, and because the least committed students may be the ones most discouraged from applying, the greater decreases in applications and admissions do not represent proportionate decreases in yield or enrollments (see p. 17-18 in the paper commissioned by UCI and Merage Foundations for the Forum entitled "A Canary in the Mineshaft? International Graduate Enrollments in Science and Engineering in the U.S." by Dr. Frank D. Bean and Dr. Susan K. Brown. It is included in the appendix.)

[7] Percent of GDP spent on research and development in 2002.

[8] Dr. Bean argued that government trends matter since government spending supports basic research more than private sector spending. Industrial spending in research is product-oriented—converting innovation into products—while government spending tends to support basic research that leads to innovation in the American economy. He also noted that overall stagnation in R and D spending and the relative decline in government basic research spending would have been far worse except for recent major increases in health sciences research from 1995 to 2004.

[9] Dr. Bean referred participants to the paper he and his colleague Dr. Susan Brown wrote for the Forum, entitled, "A Canary in the Mineshaft? International Graduate Enrollments in Science and Engineering in the U.S." It provides the basic numbers on U.S. research expenditures. It is included in the appendix.

[10] The Council of Graduate Schools' recent report, entitled **Findings from 2005 CGS International Graduate Admissions Survey 111: Admissions and Enrollment**, indicates that overall first-time enrollment of international graduate students at its U.S. member institutions increased by 1 percent from 2004 to 2005, after several years of declines. Engineering first-time enrollments were up 3 percent, and physical sciences were up 1 percent. Total enrollment of international students among

5% in life sciences and 1% in physical sciences. Dr. Stewart reminded the participants that it was only thirty years ago that the U.S. graduated the largest number of students with doctoral degrees. While the U.S. still graduates more students with doctoral degrees than any other single country, the European Union surpassed the U.S. in l999. Asia is catching up. China and India have committed to building the world's best science and engineering programs. She suggested that the U.S. faces increasing competition for the best graduate students in science and engineering from universities in other nations.

Our share of the world's science and engineering graduates at all degree levels is declining rapidly because college enrollments at graduate and undergraduate levels have expanded in other countries at a faster rate than in the U.S. What other nations are doing to secure graduate students merits our attention if we are to recruit top international and, indeed, American students. The U.S. must strengthen graduate education and provide more attractive career options.

Increased competition to recruit science and engineering students from abroad will become more intense, said Dr. Laurel Haak, Program Officer, National Academies.[11] Like Dr. Stewart, Dr. Haak called attention to the increasing number of universities in other countries that have become fine educational centers. Many times, foreign universities offer better incentives to international students than U.S. universities. The U.S. must provide a more welcoming environment. It should reduce or eliminate impediments which may hinder visa applications from international students to the U.S., such as the requirement that students must demonstrate the intent to return to their home country. It should expand opportunities for international students to remain in the U.S. and work after graduation.[12] While there is no evidence at the present time that the quality of graduate students from other nations has lessened, we should be concerned that recent declines in applications are more than a temporary idiosyncrasy. [13]

Dr. Keith Maskus, Chairperson, Economics Department, University of Colorado, Boulder, focused on the potential impact of a long-term decline of foreign graduate students, particularly students of science and engineering. He indicated that it is real and significant. His studies with colleagues, associated with the World Bank, suggest that a 10 percent increase in the number of foreign graduate students would increase patent applications by 4.7 percent, university patent grants by 5.3 percent and non-university patent grants by 6.7 percent. The marginal productivity of an additional foreign graduate student is 0.62 patent awards. Clearly, reductions in foreign graduate students due to visa restrictions or other variables could significantly reduce U.S. innovation. Technological improvements in the U.S. have been driven, to a large extent, by the U.S. rate of innovation. The rate has been growing in recent years as measured by the rapidly increased number of patents awarded to U.S. businesses and universities.[14]

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responding institutions is down 3 percent. (The Council of Graduate Schools has 450 members. Over 125 institutions responded, including over 80 percent of the institutions in the top 25 of international student enrollment.) Dr. Stewart, President of the Council of Graduate Schools stated at the Forum that returning to pre-2002 levels will require that the U.S. continue and enhance current efforts to attract the best and brightest students.

[11] Dr. Haak was Study Director of the recently completed report **Policy Implications of International Graduate Students and Post Doctoral Scholars in the United States**, National Academies Press, Washington, D.C.

[12] Dr. Haak referred to the just-published report of the National Academies, **Policy Implications of International Graduate Students and Postdoctoral Scholars in the U.S**. (Washington, DC 2005). It contains a range of recommendations to encourage foreign students to study and work in the U.S.

[13] Dr. Haak indicated that university size may be an important factor in weighing how important the decline in international student enrollment is to individual institutions. Larger universities can probably ride out short-term downturns. Smaller universities may not be able to continue to offer whole programs or courses. Their foreign student enrollment is relatively small but often strategic for certain programs.

[14] Dr. Maskus suggested that the results of his study were intriguing and robust to a number of specification tests described in the paper. However, additional work with micro-level data on foreign and domestic graduate enrollments by university seems important to test for more refined results. See the paper by Dr. Maskus and his colleagues Gnanaraj Chellaraj and Aaditya Mattoo titled "International Graduate Students and U.S. Innovation" provided to the Forum. It is included in the appendix. The paper was

According to Dr. Daniel Goroff, Vice President and Dean of the Faculty, Harvey Mudd College,[15] economists see few classical signs of immediate shortage in the labor markets for scientists and engineers. This has largely been due to the supply of foreign-born talent. There are certain types of positions, of course, that foreigners are ineligible for, due to security considerations. In the case of mathematicians, the government would not be able to hire all the citizens its needs to work on codes, data mining, and other technical problems if not for the many mathematicians from abroad filling non-classified roles throughout the rest of the economy.

Goroff supported development of a strategy to increase the admission of international graduate students desiring to study science and engineering as well as scientists and engineers. But Goroff reminded participants that counting people does not tell the whole story. If the ability of innovation to deliver long-term benefits depends only on the absolute number of scientists and engineers present within our country, then, in his terms, we have already lost and are unlikely to catch up. However, useful innovations are more likely to be generated and exploited by networks than by individuals working alone. New ideas, no matter how discovered, travel quickly across borders. Networks that facilitate trust, communication and cooperation are what help make new businesses profitable, productive and sustainable. Immigration policy should be concerned not only with importing the human capital of talented individuals, but with also developing the social capital represented by networks. To expand international collaboration, similar to reform of international student and scientist admission procedures, will require a rethinking of current national security policies and regulations.

## Participant Dialogue

Determination of how many and what percentage of international undergraduate students go on to graduate school in science and engineering programs is difficult. It is not easy to trace whether foreign graduate students who earn their masters degrees apply and enroll in Ph.D. programs. It is also not easy to calculate precisely how many foreign students are in the country at any one point in time.[16] Regrettably, there is no integrated data bank concerning student characteristics and trends that is available to develop strategic analysis. Data systems that do exist are often operated independently and are not user friendly. Researchers are often dependent on individual universities and businesses for relevant analytical data and the data secured are not always comparable or useful.

University participants agreed that international graduate students help provide sufficient numbers and resources for needed, advanced graduate courses in science and engineering. They provide scale and diversity with regard to new or amended curriculum options. International students help support research programs vital to the country's economic growth, technological preeminence and defense security.[17] Limiting qualified foreign students makes no sense given the nation's need to increase technologically related productivity growth as well as managerial, product and service innovation. Indeed, the nation should proactively seek out international students in science and engineering disciplines. America should

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abstracted for the Forum from an earlier manuscript called "The Contribution of Skilled Immigration and International Graduate Students to U.S. Innovation," University of Colorado Working Paper, 2004.

[15] Dr. Goroff was Co-Director of the Scientific and Engineering Workforce Project, National Bureau of Economic Research.

[16] Most international students appear concentrated at the Ph.D. level. According to Dr. Goroff, some of the data sources are quite good, such as the Survey of Earned Doctorates. Other sources are weak or uneven. The Department of Homeland Security and Department of State have wildly different estimates about how many foreign students are studying in the U.S.

[17] 38 percent of all doctoral-level employees in the U.S. in 2000 were foreign-born; foreign-born faculty who earned their doctoral degrees in U.S. universities constituted 20.4 percent of all faculty. In engineering, foreign-born faculty were nearly 35 percent of all faculty. The proportion of foreign-born new Ph.D. graduates going into industry in U.S. is 43 percent for math, 42 percent for civil engineering, 41percent for electrical engineering, 40 percent from mechanical engineering, and 38 percent in computer science (page 5 and 6 in the report titled **Policy Implications of International Graduate Students and Postdoctoral Scholars in the U.S. by the National Academies, 2005.** The report was distributed at the Forum by Dr. Laurel Haak.)

not take for granted that sufficient numbers of international scholars will always be present in our classrooms as well as laboratories to address the research needs of the nation's universities and economic growth. If data after 9/11 concerning applications and indeed enrollments are a prologue to the future, they may not be.[18]

Regrettably, the U.S. is not as attractive to foreign students as it once was. Visa restrictions combined with budget constraints, in part related to the relative decline of federal expenditures for research and development and in part related to cutbacks in state resources, have reduced the magnet effect of science and engineering research programs in many graduate schools. Fewer and less amply funded scholarships, fellowships and post-doctoral awards also have muted the drawing power of U.S. university graduate programs in science and engineering.

New forms of international collaboration may help make up for temporary shortfalls in science and engineering graduates entering the job market. But, most participants agreed that a long-term decline in the number and percentage of foreign graduate students applying and attending U.S. graduate programs in science and engineering ultimately would have a harmful effect on the U.S. economy.

International students, particularly those that stay in the U.S. and participate in research and development in businesses or universities, help raise U.S. productivity, expand the number of jobs, and, over time, increase the wages of U.S. workers.[19] They contribute significantly to the ability of businesses to produce innovative products and services. Without a major increase in the number of American science and engineering students, a significant downward trend in our ability to attract the best foreign students will threaten the quality of basic as well as applied R and D programs in universities. Similarly, a significant downward trend in foreign students will weaken university teaching and curriculum.

Substitution, if it exists, is not extensive.[20] International students do not appear to be crowding out U.S. students.[21] Indeed, the U.S. is not producing enough native-born students in science and engineering.[22] While leading universities, in at least one major study, recently illustrated the largest increases in foreign student enrollment at the graduate level and perhaps the largest declines in enrollment of U.S. citizens, several studies indicate that women and minorities were not being displaced in the admissions process. In addition, competition from international students did not seem to be the major cause leading to the decline of white male enrollment in science and engineering graduate programs. White males likely selected graduate studies that lead to higher paying career opportunities[23] and less complex and difficult degree

[18] While enrollment data show modest improvements, application data is still down. As indicated by many Forum participants, we do not know the precise relationship between visa, application, admission, and enrollment data. As relevant, we have yet to determine the link between numbers and quality of international student.

[19] See paper entitled "International Graduate Students and U.S. Innovation" by Gnanaraj Chellaraj, Keith E Maskus, and Aaditya Mattoo." The paper is included in appendix.

[20] Some participants suggested that the increase in the numbers of foreign scientists, engineers and physicists may depress wage levels and reduce incentives of American high school and college students to choose careers in science and engineering. Others argued that the demand for high-tech professionals worldwide will likely make any significant wage differentials relatively temporary. Most felt that increased numbers of foreign scientists and engineers were essential until major reforms occur in the U.S. education system. Paraphrasing several comments by participants, many, if not most, public schools at the present time do not offer quality opportunities for their students to study and excel in science and engineering. Until they do, the number of graduating American-born scientists and engineers in the U.S. will not be sufficient to assure the nation's technological preeminence.

[21] Many universities have increased the size of their graduate programs, permitting them to accommodate foreign students more easily without penalizing American-born students.

[22] Dr. Frank Bean argued that the relative small size of the age cohort of American students likely to enter college has led to fewer applications and has been a factor in the numbers indicating an increased proportion of foreign to American born students.

[23] Forum participants Dr. Laurel Haak and Dr. Debra Stewart referred to the recent National Academies report, **Policy Implications of International Graduate Students and Postdoctoral Scholars in the U.S.**

programs. Students accurately believed that, on average, MBA, law and medical school graduates earned much higher salaries than scientists and engineers.

Large numbers of American high school students appear to find it difficult to meet college admission standards for science and engineering programs. Regrettably, many American students do not receive a good education in science, math and physics. While there are some exceptions, particularly in the more affluent suburbs, most public schools do not grant science and engineering related courses priority in their curriculum. They are poorly equipped. Science and math teachers are often ill trained and poorly paid. States, and school districts, when faced with the scarcity of resources, often cut back on science and math programs because these programs lack strong constituencies among parents, business groups and teachers.[24]

Irrespective of their quality, high school students often shy away from taking science and math courses. They choose to major in fields other than science and engineering, in part because they find them less taxing. For some students, choice of course and degree options is based on perceptions concerning attractive job choices after college. Careers in science and engineering often are seen as less economically rewarding.[25] They are less structured and, for those passionate about research, seemingly less inviting.[26]

## Business Perceptions: The Importance of Foreign Students to the Economy and to Business

Dr. Henry Samueli, Chairman of the Board of Broadcom Corp., expressed concern that America would be shortsighted if it failed to secure the best students in science and engineering irrespective of where they were born or lived prior to applying to U.S. universities. The U.S. has always been a magnet for the best foreign students. They have been attracted by the openness as well as the freedom reflected in America and the quality of America's universities. International students who have remained in America have become some of our most outstanding scientists and engineers. Without their contributions and leadership, American universities and businesses would have found it difficult to sustain their respective dominant global education and economic leadership roles.

Business, according to Samueli, must always seek the best employees regardless of residence or nation of birth. To be competitive in a global economy demands the best. If businesses cannot secure the best scientists and technicians in the U.S., they must and will search for them abroad. Broadcom has strong international affiliations. Its offices are located in many countries. The company has hired the "best" scientists and engineers irrespective of country of origin because it both makes good economic sense and helps the company maintain its leadership role among competitors. Broadcom's local campus in Irvine is like a diverse university. Walk through it and you will see multiple nationalities among Broadcom's scientists and engineers. Broadcom's business aim is and must be to remain competitive by hiring innovative people to create innovative products.

Samueli faulted caps on current H-1B visas. He also criticized restrictions on student visas that require U.S. officials to determine whether foreign graduate students intend to remain in this country after they graduate. Succinctly, caps limiting employment and visa restrictions limiting permanent residence and employment restrict the ability of businesses to secure the best scientists and engineers. If businesses cannot hire the best, they will be required to outsource to remain competitive.

[24] International tests suggest that U.S. high school students test lower in science and math achievement than students in many other nations.

[25] Student perceptions are not wrong. On average, positions in business, law, medicine, generally, have provided and still do provide higher salaries.

[26] Participants noted that relatively few grants for research go to younger graduate students or younger researchers. The reward system in science and engineering seems premised on a "winner take all" system where experience and age trump youth.

Ted Smith, founder and Chairman of the Board of FileNet Corp., and Joel Slutzky, Chairman of Board of Iteris Corp., strongly supported Dr. Samueli's comments concerning the negative impact on the U.S. economy of a long-term decline of international graduate students in science and engineering. Smith noted that severe limitations on the number of international science and engineering students admitted to U.S. graduate programs would hurt America's lead in scientific and technological innovation and mute its productivity growth. Slutzky indicated that innovation is boundary or border resistant, particularly in today's global, "flat" economy.[27] Guidelines restricting admission of international students to the U.S., if not explicitly linked to security problems, are self-defeating and, indeed, create an economic security issue. International students as well as scientists and engineers have in the past and, if allowed, will in the future make significant contributions to America. To impede their entry and ability to stay will erode our quality of life and economic security.

Slutzky, again, reminded the participants that the marginal status of science and math programs in many public schools impedes the development of a large pool of outstanding American science and math students able to compete with the best young people from other countries for admission to American universities.

## Participant Dialogue

Participants generally agreed that businesses will not succeed in an increasingly competitive global economy by selecting second- or third-rate scientists and engineers.[28]

Some participants expressed concern that ending caps could reduce company incentives to train and upgrade the skills of existing U.S. workers as well as reduce their commitment to hire U.S. workers.

One participant noted that labor shortages in science and engineering positions appear limited to very critical disciplines or specialized niche areas within the broad categories of science and engineering. For example, U.S. security agencies (e.g., the National Security Agency) could probably hire all the Ph.D.s graduating in math each year. But indicators of general workforce shortages, like tight labor markets, low unemployment and rapidly increasing wages, do not presently exist for scientists and engineers. However, three factors could result in labor shortages that would risk U.S. security and economic growth: increased competition from other nations for scientists and engineers; restrictions on the ability of foreign graduate students to study science and engineering and, upon graduation, work in the U.S.; and a failure to generate more American scientists and engineers.

After vigorous discussion, most concurred that concerns for the bottom line will not divert most businesses from carrying out training programs for present employees and that removal of the caps on temporary visas and permanent green cards will not have a negative effect on existing employees. Existing employees will benefit from hiring outstanding new employees, whether foreign-born or American. Caps could force businesses to either hire second- and third-rate employees or outsource jobs, reducing U.S. business competitiveness and productivity. It is better to let the market and market pressures determine recruitment of personnel.[29]

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[27] Thomas L. Friedman's recently published book, **The World is Flat, A Brief History of the Twenty-First Century, Farrar**, Straus and Giroux, New York, 2005. Friedman argues that because of communication innovations, the global economic playing field has been leveled; indeed, it is flat. Countries and businesses in them can compete for markets anywhere. Intellectual work and capital can be organized, produced, and delivered using locations in different nations. The U.S. must now increasingly compete for global knowledge skills and work.

[28] Personnel "quality" or best potential employee was defined by many Forum participants in terms of particular skill sets needed by the firm, potential contributions to the firm and likely individual productivity regarding firm needs.

[29] Some participants expressed concern that removal of caps would encourage firms to seek foreign scientists and engineers because they would be able to pay them less than American scientists and engineers with the same skills. But after discussion,

The speed and ease of communication resulting from the extensive use of telecommunication and computer innovations will make the world "flat." International collaboration in scientific endeavors may blur the importance of national boundaries with respect to some inventions. But, it is foolish to deny the strategic value of being the site of product invention. Korean scientists may or may not extend their innovative minds to other nations regarding stem cell research. However, if they do so, it likely will come at a price. Unless some country or company buys the research team, Korea and its research team will secure "first mover" advantages. First movers of new innovations capitalize more frequently on diverse economic benefits. They are able to leverage international investment, gain patent protection, develop derivative products, create ancillary companies, and increase employment. The U.S. and its businesses must retain first mover status in high technology and scientific innovation. To do so, the U.S. and its businesses will require successfully competing for the best foreign students, scientists and engineers.

The present system of immigration caps and quotas retards America's ability to meet its needs for international students as well as international scientists and engineers. Historically, caps and quotas were related more to diverse immigration policies than to major security concerns. Even after 9/11, most policy makers have not viewed caps and quotas as part of a security strategy. Caps and quotas were and remain a way to control and structure immigration flows as well as immigration categories. They often result from political pressures and generally vary with economic cycles. Only in the mid-nineties did immigration laws and regulation seriously recognize specific U.S. employment needs in high technology.

Current immigration laws limit the ability of U.S. firms and universities to compete with many foreign companies and universities on an equal footing for students and for scientists and engineers. For example, the 214(b) "intent to return home" stipulation requires a subjective judgment by U.S. consular officers regarding student visa applications and, as one participant noted, provides an opportunity for consular officers to make other very subjective judgments. The provision is over fifty years old and out of date. Young people in different nations read it correctly as limiting their ability to stay in the U.S. after graduation to seek employment. It is not the best way to encourage students to apply to U.S. universities. It is counterproductive. Policy makers tell us they want to encourage foreign students to come here and find employment after graduation; our universities tell us they want and need foreign students to buttress their curriculum and R and D programs; our businesses tell us they need to recruit the best science and engineering students, including foreign students. If all this is true, the U.S. should consider eliminating or amending 214(b).

Perhaps, in the long term, we should consider a comprehensive revision of the nation's immigration laws. The current permanent immigration quotas associated with permanent visas grant priority to family reunification rather than U.S. labor needs, even in the highly and very highly skilled scientific and technical categories. Too often there are relatively few permanent green cards available for scientists and engineers.

Other factors, also, obstruct efforts to expand the pool of potential science and engineering talent allowed to come to America from other nations. Spouses and children of immigrants are counted as part of the quota in different employment categories, which reduces the number of available visas for scientists and engineers. At the same time, the backlog associated with the review and approvals of employment based

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most participants felt that the U.S. needed international students and scientists and engineers in order to make up for the absence of sufficient numbers of American scientists and engineers. Over time, severe restrictions on international students and scientists as well as engineers might generate a market response and salaries that would entice a larger pool of high school students willing to entertain science and engineering careers. But predicting how the market would respond given other variables (e.g., wage levels in other professions, U.S. commitments concerning research and development) is difficult. The waiting period before the market catches up could be relatively long and the negative effect on the U.S. dominance in science and technology real. This possibility, if it occurred, would reduce American prosperity and ability to compete in the global innovation economy.

visas is years long in some key high-tech categories. Moreover, it is difficult to transfer underused slots from one employment category to another.

The U.S. should put in place a seamless, non-bureaucratic structure to manage student as well as H-1B visas and requests for permanent residency as well as citizenship. It should be premised in part on strategic U.S. economic needs and objectives.

Businesses and universities must make their case to reform current laws and regulations in a more strategic way than both have up to now. They must provide solid analysis to support the negative economic consequences resulting from provisions that limit the ability of international students, scientists and engineers to enter, study and work in the U.S. Development of a brief paper documenting the link between restrictions on international students, scientists and engineers and economic security would be helpful. The economic security arguments are important and, if supported by solid data and analysis, could gain traction within the security, counterintelligence and counter-proliferation communities, as well as with Congressional leaders, the White House, the State Department, and Homeland Security officials. Increasingly effective technology associated with visa and surveillance processes will increase the confidence of senior security staff and permit the consideration of alternative ways to lessen immigration bureaucracy and facilitate reform of immigration laws.

Participants agreed with the need to address and, where possible, redress current restrictions that unnecessarily inhibit the entrance and employment of international students, scientists and engineers. But they also agreed that simultaneously America must think through how it educates and trains future scientists and engineers. The country could gain more "bang for the buck," so to speak, if it consciously helped to change the normative framework most Americans and some scientists apply to science and engineering. The nation needs to move from a tournament or "winner-take-all mentality" to an appreciation of collaboration and team effort in scientific endeavors. These new mindsets may run up against U.S. government regulations impeding scientific research collaboration, particularly in key security related areas of concern. But government should be pushed to prove the wisdom of and need for current limits on international research collaboration and should be asked to redefine security interests in ways that make sense concerning exports linked to scientific research. The ease of communication generated by 21st century technology makes it difficult to restrain interaction concerning research among professional scientists and engineers from different nations. The U.S. should impose limits only when they are necessary from a security and defense standpoint. Further, what is now necessary should not be fixed or cast in stone, given the likelihood of continuous improvements in U.S. surveillance capacity and the increasing difficulty of keeping secrets.

Regulations limiting research collaboration and intellectual or deemed exports[30] should be streamlined, and the areas of scientific concern that are declared off limits justified and narrowed in light of the increasing

[30] After 9/11, the U.S. granted increased emphasis to the prohibition of "deemed exports"—exports that take place through the transfer of information to a foreign student or scientist studying at a U.S. college, even those who have received Security Advisory Opinions (SAO) clearance. The U.S. has considered whether "there were sensitive fields, including fields that have a direct application to the development and use of weapons of mass destruction, to which international students should not be admitted …. Universities have reported a substantial increase in situations in which a federal sponsor of research includes award language that restricts the dissemination of research results or the participation of foreign nationals without prior approval on specified research projects."(See **The National Academies, Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States**, Washington DC, 2005, p. 83-84.
The New York Times reported on November 26, 2005 that the U.S. Department of Commerce wants to tighten deemed export regulations based on Department of Defense recommendations. For example, the Department of Commerce proposes that the country of birth of a foreign laboratory worker not current citizenship should be used to determine need for licenses. Further, if the New York Times is correct, contractors including universities securing research funds would be required to create separate security badges for foreign citizens and segregated work areas for researchers using controlled technology. Universities,

capacity of other nations to match U.S. scientific expertise and given the benefits to the U.S. from scientific collaboration.[31]

## A First Class University Needs First Class Minds

Dr. Robert Dynes, President of the University of California, indicated that the University of California will continue to work with the nation's leaders to increase their understanding of the threat to U.S. security posed by restrictions on foreign graduate students. The University of California has always welcomed international students. The system's ability to graduate outstanding international students at the graduate level has been an economic asset to the nation, the state and the university. International students enrich the campus and classroom. Foreign student graduates who remain in the U.S. make significant contributions to the quality of life in America and to America's economic success. Students who return home after graduation often become leaders in their own nations. They become ambassadors of good will for America. They provide Americans with useful business, academic and diplomatic networks. The U.S. must cultivate a culture of intellectual hospitality.

President Dynes expressed concern that the University of California and the State of California would suffer if the decline in international graduate school enrollments, particularly in science and engineering programs, continues for a long period of time. The recent downward trend in foreign student applications and enrollment at the campuses of the University of California is disturbing. While the numbers have seemingly begun to move upward again, most University of California campuses have not been able to return to pre-9/11 levels. In the life sciences, foreign graduate enrollment dropped steadily from a 2001 high of 207 out of 967 students. or 21 percent, to a 2004 low of 168 out of 1136 students, or 15 percent. In the physical sciences, foreign graduate enrollment dropped from a 2001 high of 159 out of 692 students, or 23 percent, to a 2004 low of 97 out of 613 students, or 16 percent. In engineering and computer sciences, foreign graduate enrollment dropped from a 2001 high of 889 out of 1948 students, or 46 percent, to a 2004 low of 628 out of 1944 students, or 32 percent.

President Dynes noted the ongoing decline in support for graduate studies. Along with cost-of- living increases and increases in fees and out-of-state tuition, diminished state resources hamper the University's ability to attract international graduate students, including science and engineering students.

The President described some of the initiatives the University has taken to encourage international graduate student enrollment and to make the financial burdens on them easier once they attend the University. For example, the Regents of the University of California recently endorsed his recommendation to exempt graduate students from non-resident tuition hikes. Further, the University system will extend increased student support in some key graduate programs. Finally, the President indicated that he has recommended that international graduate students should not pay out-of-state fees after they move to degree candidacy.

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apparently, have responded with concern to the proposed new regulations. They have indicated that tighter restrictions could backfire and hurt national security by limiting scientific progress. According to the New York Times, Barry Toiv of the Association of American Universities suggests that if the regulations are adopted, "research that benefits both our economy and our needed national security just won't happen."

[31] Several participants noted that it is possible that private sector needs regarding collaboration may conflict with government needs regarding national security. Private sector interests they suggested are fluid and will flow legitimately where monetary gain is highest. National security needs may not always be consistent with private sector interests in foreign countries Others argued with this perception and suggested that private sector and public sector interests in science and technology generally are consistent and can be made more so through conscious dialogue and careful government planning. Given today's communication systems, it is tough and will be tougher to put a restrictive boundary around collaboration. An over-restrictive set of regulations will only hurt U.S. efforts to insure that it is a leader in the innovation economy.

The University of California is trying to build up relationships with universities in other nations. It is exploring with China a “ten by ten” collaboration; in effect, the ten universities of the UC system would work with ten universities in China. Building linkages between institutions as well as among their faculty and students will increase the likelihood of reciprocal educational, teaching and research relationships. It will also encourage Chinese students and scientists to study and work in the U.S. and enhance the ability of U.S. businesses to recruit Chinese scientists and engineers.

President Dynes noted the significant commitment of the University to upgrade the teaching and curriculum of public schools in California, particularly with regard to their science courses. He described efforts to extend opportunities and incentives for would-be teachers of science to study at the University of California and improve their teaching skills. The University is aiming to help 10,000 teachers in the state over the next ten years.

## Participant Dialogue

Many participants sought to identify the main obstacles limiting university recruitment of international students. President Dynes acknowledged some of the difficulties. The legislature requires foreign students to pay out-of-state tuition. Cutbacks in state funding combined with the legislature’s emphasis on undergraduate education have severely limited recruitment flexibility and resources. The University of California does not have the resources to provide sufficient assistance to international students.

Other participants noted that because of the unpredictability of the visa process, universities are often wary of mounting new courses or clusters of courses of relevance to foreign and domestic students. The cutback in and failure to increase federal research funds in some key scientific areas also have caused problems for universities in creating research opportunities for foreign students. Federal funding has been unpredictable. It has gone up in some areas such as life sciences but has either stayed flat or gone down in other areas.

Participants indicated that while the Departments of State and Homeland Security have made strides in developing a more efficient visa process, the process is still relatively difficult for foreign students. It often requires travel to distant consular offices. Consular decisions are not subject to administrative appeal and the process is not very transparent. The requirement that foreign students indicate they will not remain in the U.S. after graduation is a real obstacle. International students now have options to attend improved universities in their own nations. Quite often, they receive more competitive aid packages either from their own universities or universities in other nations—nations with fewer visa restrictions and a simpler visa process.

While the State Department has reduced approval time associated with the student visa approvals, it is impossible to know how many students fail to apply for visas because of what they perceive is a difficult visa process and an unwelcoming environment for international students in the U.S. Many participants expressed concern that the problems associated with the visa process have disrupted carefully built networks with undergraduate programs in other nations—networks that help stimulate applications from their best students to U.S. graduate schools of science and engineering.

Efforts to attract more international students as well as scientists and engineers often are negatively affected by the sometimes strident national debate in America over general immigration issues. Universities and businesses must join together to advocate the need for both the increased admission as well as retention of foreign graduate students desiring to study science and engineering and the increased ability of foreign scientists and engineers to live and work in the U.S.

## Perspectives from Diverse Universities

The Massachusetts Institute of Technology and the University of California, Los Angeles, one a private and the other a public university, one on the east coast and one on the west coast, faced the same post 9/11 decline in the number of foreign student applications and enrollments in their respective graduate programs in science and engineering. Chancellor Phillip Clay of MIT and Provost Daniel Neumann of UCLA projected problems with respect to their institutions if the reduction in the number of applications and enrollment of foreign students continues for a long time. They indicated that foreign graduate students add an important dimension to the classroom and to faculty and student research endeavors. Their experiences are different from U.S. students, and many are better prepared than U.S. students. The interaction between international and American students helps enrich the learning experiences of both sets of students. Resource limits for student assistance combined with visa problems and student perceptions of unfriendly U.S. and campus environments are the key issues impeding the number of international student applications.

Foreign students may go elsewhere because of animosity toward U.S. foreign policy in their countries.

International students feel they face an uncertain future if, after graduation, they would like to remain in the U.S. to work in business, universities or "think tanks." Other nations encourage international students to remain in their countries after graduation. America in many ways does the opposite. Being able to work in the U.S. after graduation is an important incentive to students thinking about graduate school. The nation should change current laws to make it crystal clear that graduating international science and engineering students can stay and work in the U.S. Their ability to find employment in the U.S. has in the past and will increasingly in the future help the U.S. remain a science and technology leader.

Both MIT and UCLA are engaged in innovative marketing programs to attract and retain foreign students. MIT sends teams of faculty and students abroad to engage in particular problem-solving efforts of relevance to the quality of life in participating nations. UCLA has encouraged faculty and student exchanges and is participating in President Dyne's effort to build institutional bridges to other nations. Both universities are sensitive to possible hostility to foreign students on campus and in the surrounding community. They have initiated discussions with international students and community leaders to help make both groups aware of possible problems and to develop ameliorative strategies.

Provost Gene Levy from Rice University and Provost Tom Sullivan of the University of Minnesota shared their experiences concerning international students with participants. Both institutions evidenced a decline in applications and enrollment after 9/11, but both Provosts believed that the numbers had begun to turn around. They agreed with their colleagues from MIT and UCLA that avoidance of a permanent downturn in applications and enrollment will depend on multiple coordinated actions by government, universities and the private sector.

Provost Levy worried that the U.S. is probably better at responding to short-term immediate threats or risks than at reacting to slowly emerging threats and risks. Dramatic provocations like 9/11 that appear to threaten survival and safety evoke dramatic responses, while slowly developing threats to our national ascendancy may or may not evoke a strategic response. If the recent downward trend in foreign student applications and enrollments continues, and if it is combined with an inability to significantly increase the number of American scientists and engineers, the U.S. will face a slowly developing threat to its scientific dominance. The possible threat requires a coherent long term national response.

Provost Levy indicated that American ascendancy is not historically inevitable. The advent of rapid travel and communications makes the "secrets" of American success visible to all. It is unreasonable to believe that other nations will forego seeking to match American enterprise and success. As other countries provide

more educational opportunities and meaningful jobs, they may be able to out-compete the U.S. for the best minds. For the U.S., the question of winning may become less important than the question of prospering in a flatter, more competitive global economy. Post-9/11 restrictions on international students and scientists have and, if not amended, will continue to exacerbate the U.S. competitive situation. They make the U.S. a less inviting destination while other nations are working harder to become more inviting to international students. In the face of growing world competition from Europe, Japan, China, and India, the U.S. cannot afford to devote overwhelming attention to perceived short-term threats and relegate longer-term, important economic risks to lower priority. The nation does itself an enormous disservice by subscribing to the incorrect view that it remains the source of all that is new, important and strategically valuable. In dwelling too much on the need to keep secrets and shield ourselves from foreign nationals, we may, on balance, be simply separating ourselves as a nation from a large portion of the world's creative potential. Making it hard for foreign nationals to come to the U.S. and making it uncomfortable for them to live and work here will ultimately damage America's self-interest. Aside from visa and immigration policy impediments, overly restrictive "deemed export" regulations potentially harm America's self-interest in attracting the best foreign scientists and engineers and in fostering collaborative efforts between U.S. and other nations' scientists and engineers.

Provost Sullivan argued strongly that the U.S. must become a more welcoming place for foreign students. We must work hard at changing the perceptions held by many foreign students and scientists that the U.S. does not really want them. Extending visas periods, increased transparency in the visa process, permitting students to administratively appeal negative decisions concerning visas by consular offices, allowing students to easily stay and work in the U.S. after graduation, and extending caps or quotas to permit permanent residency and employment will help the U.S. attract international science and engineers students as well as scientists and engineers.

Scholarship and fellowship money must be found to help narrow the gap between American student and foreign student tuition. Further, state legislatures must become convinced that foreign students are a real economic asset to their states. They should consider tuition adjustments for foreign students. Businesses need to join with universities to develop joint marketing and financial aid programs that attract international graduate students in science and engineering as well as scientists and engineers to our shores.

## Participant Dialogue

Participants generally agreed with the policy menu suggested by the Chancellor and Provosts. Several indicated that universities, with some exceptions, had not made their case concerning the importance of foreign students to the public or publics. Universities need to convert skepticism among some legislators and community leaders that their argument to increase foreign student admissions is more than a fiscal one. The fiscal health of universities is critical, and its link to revenue provided by foreign student tuition is important. However, equally important to establish are the linkages between increased foreign student enrollment and the excellence of university teaching and research programs for all students.

Participants urged universities to do a better job at international marketing. They agreed that universities must collaborate with business in developing and carrying out coordinated marketing efforts.

Many participants applauded university efforts to initiate closer links with public schools in their states and communities. Legislatures in most states want universities to serve undergraduate students. Universities should reach out in innovative ways to recruit U.S. high school students to their undergraduate programs in science and engineering. Working partnerships with elementary and secondary schools to define curriculum standards and to improve curriculum and teaching would strengthen student interest in attending college and student desire to pursue careers in science and engineering.

## Balancing Security and Flexibility

Acting Undersecretary Randy Beardsworth from the U.S. Department of Homeland Security noted that the Forum had provided him with useful background concerning the problems and opportunities associated with the enrollment of foreign students in U.S. graduate programs in science and engineering. The Undersecretary promised to distribute the report of the Forum to leadership in the Departments of State and Homeland Security.

The Acting Undersecretary indicated the Department of Homeland Security's and the Administration's strong support for efforts to reduce the impediments to international student enrollment in U.S. universities. But at the same, he indicated the need after 9/11 to grant priority to security objectives, particularly with respect to closing the door on terrorists and individuals or groups desiring to access intelligence relevant to U.S. defense plans. The Acting Undersecretary described the balance between security and openness as well as the balance between security and objectives regarding international scientific collaboration as delicate ones. Both must be calibrated continuously. Border controls and surveillance are not enough. America's security is increasingly linked to its economic health, which, in turn, is dependant on its ability to compete in a global economy based on technical innovation.

The U.S. must set its sights on remaining the world's economic and technology leader. To maintain its leadership position means that the U.S. must sustain its historical and current scientific and technological preeminence. But strategies to continue the nation's scientific preeminence and its economic security could generate conflict with legitimate security objectives. According to the Acting Undersecretary, the U.S. must understand the importance of economic security as a national objective and the relationship of economic security to the nation's need to secure outstanding foreign students and the best science and engineering professionals. The nation must carefully weigh the benefits and costs of increased security regulations if they limit the enrollment of foreign students as well as access to the U.S. by foreign scientists and engineers. The decisions will not always be easy ones nor will they always portray clear cause-and-effect relationships concerning national security objectives. To the extent possible, transparency concerning the rationale for new or amended regulations will help gain public understanding if not always support.

The Undersecretary urged the Forum to generate a brief paper illustrating the impact of a long-term decline in the number of foreign graduate students and the effect of restrictions on foreign scientists and engineers that limit their ability to live and work in the U.S. on economic security and therefore overall U.S. security. The nation's increasing technological capacity to protect its borders from security risks will increase security officials' willingness to amend policies and programs that restrict student and professional admission to and employment in the U.S.

Dr. Wendy Hall, former senior staff member in the White House Office of Science and Technology Policy, supported the Acting Undersecretary's statements. Security objectives, particularly concerning the need to reduce threats from terrorists and impede the transfer of weapons of mass destruction technologies and defense secrets, deserve priority. She also agreed with the Acting Undersecretary that we can do a better job of weighing risks associated with restrictions concerning foreign students, scientists and engineers.

Clearly, the recent efforts of the Departments State and Homeland Security have improved the visa process. However, additional efficiency measures should be considered, now that SEVIS and USVISIT are operational. For example, Dr. Hall indicated that section 214(b) provisions requiring a consular judgment concerning a student's intent to return home are in need of review and amendment. They were developed for a different purpose in a different era. They are no longer consistent with current needs, global realities and existing commitments to increase the admission of foreign students and the employment of top foreign scientists and engineers.

Dr. Hall described the difficulty some foreign students have in reentering the country after they visit parents and friends or attend conferences outside the country. Sometimes reentry requires a new visa and enduring the visa process multiple times. The U.S. should consider granting multiple entry or access for international students and other categories of international guests who are registered in SEVIS, provided that the Department of Homeland Security is granted greater discretionary removal authority should an international student or guest become a national security risk after entry.

Dr. Hall encouraged the U.S. to develop a national strategy to assure its competitiveness in a global economy. Such a strategy would provide the context for the development of realistic policy and program options regarding admission of outstanding foreign students and professionals to the country. It would define principles and policies governing admission to and employment in the country of international science and engineering students as well as international scientists and engineers. It would be an always evolving document that would be used to encourage the development of consensus concerning policies between whatever Administration is in power, the Congress, private sector, university and community leaders. It would be used to help coordinate implementation across relevant agencies of Administration policies concerning the immigration to America of international students, scientists and engineers.

Dr. Hall expressed concern that current security policy discussions, often, do not include individuals who can articulate the benefits of attracting international graduate students desiring to study science and engineering as well as international scientists and engineers to America.
She indicated that the U.S. government often sets security policies without having key research officials at the table. Scientists and engineers from key federal agencies whose main business is knowledge-generation should be invited to engage with security officials whose primary mandate is to limit knowledge-exchange. Adding scientists and engineers to relevant policy deliberations would help eliminate the present one-sided nature of the policy development process and provide a better balance between national security and economic security objectives.

## Participant Dialogue

Comments from the Acting Undersecretary and Dr. Hall were met with a positive reaction from participants. The general view was that the proposed paper suggested by the Undersecretary, if developed, could help convince officials that a better calibration is needed between immigration regulations and national economic as well as security objectives. Generally, participants welcomed the Acting Undersecretary's openness and his willingness to continue the dialogue beyond the Forum.

Participants supported Dr. Hall's proposal to develop a comprehensive competitiveness strategy to set a context for establishing access policies for international graduate students and science and engineering professionals. Long-range planning has never been the strong suite of policymaking in the U.S. Unfortunately, "muddling through" and incrementalism have been the norm. What is being proposed will add more analytical capacity to the continuous development of policies and programs. If combined with improved risk-analysis concerning the effect of alternatives on economic and homeland security, policy and program decisions would reflect a better balance between economic security and national security considerations as well as between openness and security.

Dr. Hall's advocacy of increased involvement of scientists and engineers in federal government decision making concerning admission to and retention of international students and scientists and engineers in the U.S. received high praise. According to participants, such inclusion would seem essential to develop a fine line analysis of economic and homeland security issues. Several participants suggested that current deemed export regulations impeding access to the U.S. by international scientists and engineers and that limit collaboration among scientists from different countries deserves rethinking by an expanded decision-

making group. Current regulations appear out of sorts with reasonable security concerns and mute the ability of U.S. businesses and universities to secure needed intellectual capital.

## Developing Effective Policies: Problems, Challenges and Opportunities

Julie Furuta-Toy, Director of the Office of Public and Diplomatic Liaison, U.S. Department of State, provided participants with an overview of the State Department's efforts to respond to post-9/11 security concerns. She acknowledged that some of the changes in the law and regulations slowed down processing of visas and that the delays particularly in 2002 were troublesome.

Indeed, until recently, the decline in applications combined with processing delays and more visible security measures, such as expanded use of personal interviews, have contributed to the perception among businesses and universities that visa processing impedes rather than facilitates legitimate travel to U.S.

Ms. Furuta-Toy described recent efforts to make the visa system more efficient and welcoming. For example, since September 2001, the Department of State has created more than 350 new consular positions to reduce visa application review time. It has invested heavily in automation to enhance the predictability and timeliness of the visa application process. Instructions were disseminated to all embassies and consulates to give priority to students and exchange visitors. Ms. Furuta-Toy indicated that almost all visa applications—some 97 percent—are processed in one or two days. Even for the students who still face delays, the Department of State has streamlined the process to shorten the response time. The required interagency review times associated with visa mantis cases[32] have been reduced from an average of 72 to less than 14 days. Further, the State Department is pursuing increased numbers of visa reciprocity agreements between the U.S. and other nations. There are signs of success. For example, China and the U.S. have agreed to lengthen the maximum validity of business, tourist and student visas to twelve months.[33]

Stuart Anderson, Executive Director, National Foundation for American Policy, complimented the State and Homeland Security Departments on recent administrative improvements related to the student visa process and Visa Mantis procedures. However, he affirmed the need for more reforms if the U.S. is to attract increased numbers of graduate students in science and engineering and encourage increased numbers of scientists and engineers to migrate to America. The U.S. should take steps now to make sure that the recent decline in international student applications and enrollment in graduate programs of science and engineering does not become a long-term trend.[34]

Anderson provided a mini case study of a prototypical foreign student contemplating where she should do her graduate studies. The student believes that the U.S. has been unfriendly to students since 9/11. She is uncertain as to whether or not she will be able to work in the U.S. after graduation. She knows that her acceptance to a university will come before her visa approval (and related security clearances) and that she will not be able to know whether she can enroll in an American University until receiving her visa.

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[32] Visa Mantis cases are ones in which the applicant's involvement in sensitive scientific research caused U.S. concerns about transfer of sensitive technology for hostile use. Mantis cases after 9/11 led to extensive interagency reviews and an average processing time of up 72 days.

[33] Ms. Toy's comments were well received. However many participants did question whether the data showing improvement and clearly a more efficient visa related review process told the whole story. Several participants suggested that far too many international students never apply for a visa and as a result never are captured by visa application and approval statistics. These applicants often view the application and review process as very difficult, and they believe that international students are not welcome in the U.S. They now have increasing choices regarding universities in their own and other countries.

[34] See the paper prepared for the Forum by Stuart Anderson titled "International Students and U.S. Policy Choices" in the appendix.

She is afraid of the significant costs associated with attending a University in the U.S. She has an outstanding university near her home that has accepted her, and she has been courted by an excellent university in the United Kingdom that has promised her significant financial support. The decision is a difficult one.

Anderson recommended that the Forum participants consider the following:

- An amendment to 214(b) of the Immigration and Nationality Act that would exclude international graduate students planning to attend U.S. university science and engineering programs from its requirement that students applying for visas illustrate their intent to return home after graduation.[35]

- The streamlining of immigration procedures to permit graduating international students to secure green cards relatively quickly.[36]

- The appointment of a senior official, preferably in the White House, to act as a coordinator of student and scientific visas and an ombudsman to expedite changes in visa and visa mantis procedures.[37]

- The development of a partnership between business, foundations and universities to establish a major national international student scholarship/fellowship fund.

- The development by government, business, and universities of an innovative comprehensive marketing plan to attract foreign students. The plan should involve strategic and coordinated advertising, speeches, colloquia and forums.[38]

- The use of the U.S. Agency for International Development programs to provide need based vouchers and possible scholarship and fellowship funds to foreign governments to distribute to their worthy science and engineering students who desire to study in the U.S.[39]

## Participant Dialogue and Forum Recommendations

After some intense discussion concerning the wisdom of developing a comprehensive set of recommendations to overhaul current legislation and regulations pertaining to foreign students, scientists,

[35] Anderson noted that the cap on H-1B visas for students was increased recently by 20,000 for international graduate students completing degrees in the U.S. and seeking to work in the U.S. At a minimum, the requirements of 214(b) and the new law conflict in spirit. Congress might be willing to address the removal of 214(b) requirements concerning the intent to return for international graduate students.

[36] One approach would be to allow employers to pay a fee (premium processing) for faster green card processing. If this approach is combined with quicker labor certification, processing could result in green cards within 90 days. Doing this would allow international students to know in advance that they could remain in the country to work and live permanently. Both approaches if used together would enhance the U.S. ability to secure foreign students. Both approaches would provide a major competitive edge for U.S. universities, companies and research facilities.

[37] The U.S. government now places international student responsibilities in several offices and a number of agencies. Increased coordination would make the process more efficient and effective.

[38] The U.S. has not initiated a continuous effective visible marketing plan to secure international students and compete with other nations for foreign students.

[39] The U.S. government has a major role to play in welcoming students. Its existing financial aid programs are too small to make a dent. The U.S. Agency for International Development program could make a difference. Even if assisted foreign students return to their country after completing their studies, the U.S. would benefit. Most students would become positive ambassadors for America; many would join global firms with U.S. ties; some would help build linkages between U.S. universities and firms and their nations' universities and firms. The return on the U.S. government's investment would be significant.

and engineers, participants agreed that while such an overhaul is needed neither the Administration nor Congress would be receptive at the present time. The reform process would be unpredictable and students as well as high-tech professionals could end up with more restrictions than are on the books currently.

Participants agreed to consider a discrete strategic set of policy and program recommendations for amending current laws and regulations to the extent consistent with security needs. They concurred on the need to develop statutory and regulatory reforms that would make it easier for graduate students in science and engineering to remain in the U.S. after graduation and that would encourage international scientists and engineers to come to America to live and work. Both objectives were seen as essential to economic security and national security. The recommendations of the participants in the Forum were as follows.

**Government**

1. The Administration and Congress should ask an independent group of respected organizations (e.g., the National Academy of Sciences, the Council of Graduate Schools, the Forum) to develop a strategic paper defining the relationship of international graduate students and international scientists and engineers who wish to migrate to and work in the U.S. to the nation's economic security. To the extent possible, the paper should estimate the need for scientists and engineers in the U.S. based on alternate economic and job growth scenarios. It should calculate the benefits and costs associated with the immigration of international students and scientists and engineers to the U.S. to fill projected job needs related to each scenario.[40] Once finished, the paper should be widely distributed and used to frame the reform of existing visa and security policies.

2. Congress should amend section 214b. International student visa applicants, particularly graduate student applicants desiring to study in U.S. university science and engineering programs, should be exempt from the present prerequisite that they prove or show evidence of an intent to return home. Further, the Administration and Congress should provide international graduate students who graduate in science and engineering streamlined access to a green card. Additionally, Congress should allow employers to pay an extra premium processing fee to accelerate relevant green card reviews and to permit international graduate students to secure H-1B visas (and repetitive renewals) until they secure green cards.

3. The Department of State should grant visas for international students that allow for multiple entries to the U.S. Student applicants should know that they can easily return home to visit family and friends and attend conferences without having to secure new visas.[41]

4. Congress should expand the number of employment-based immigrant visas or green cards. Similarly, Congress should increase the caps and quotas associated with H-1B visas and permanent status or green cards for scientists and engineers essential to U.S. economic and national security. Congress should eliminate the requirement that spouses and children count in the calculations of employment-based immigrant quotas for scientists and engineers.

5. The Administration should mandate the continuous involvement of scientists and engineers from relevant federal agencies at the policy table when policy decisions are made concerning placing restrictions on international students and scientists and engineers. Their involvement would help

[40] The paper should focus on measuring the benefits and costs to the general economy, to individual sectors of the economy, to universities, and to the quality of life in America.

[41] Several participants noted that multiple access visas often generate from reciprocal agreements. One participant indicated that multiple access visas are now essentially a problem for only Chinese and Russian students. During discussions, some participants suggested that holding multiple access visas hostage to reciprocal agreements may delay the benefits associated with increasing access to U.S. graduate schools by international graduate science and engineering students.

insure a balance between national and economic security considerations as well as between national security objectives and America's need for and commitment to the benefits resulting from international scientific collaboration.

6. The Administration, working with business as well as university leaders, should develop a coherent coordinated marketing plan to encourage international students, scientists and engineers to come to the U.S. The plan should avoid puffery. It should focus on the advantages of education in the U.S as well as on alternative ways that international students can remain and work in the U.S. It should describe existing financial assistance programs.

7. The Administration should require consular decisions concerning visas to be more transparent. Students and professionals should be informed of the status of their respective applications and, unless security considerations are involved, the reasons for visa refusals. The State Department should provide preliminary approval of visas to potential students preceding their applications to American universities. Failure to do so places students in a difficult position. Students are unable to respond to university acceptances until they receive visa approvals. Doubt concerning visa approval creates doubt concerning the wisdom of submitting applications to U.S. universities.

8. The Administration and Congress should provide assistance for international graduate students, particularly science and engineering students, through the programs of the U.S. Agency for International Development. Presently, U.S. student support programs are relatively small and unfocused.

   Using foreign aid assistance mechanisms would benefit international graduate students, the assisted nation and the economic security as well as competitiveness of the U.S.

9. The Administration and Congress should evaluate the impact of the downward trend in federal research and development support to universities relative to the growth of the economy. Increased predictable support for basic science and engineering research is essential to strength the ability of the nation to compete in a global innovation economy.

10. The Administration and Congress should acknowledge the relationship between inferior public schools and the need to expand enrollment of American students in undergraduate and graduate programs in science and engineering. The nation should commit to developing, supporting and executing policies and programs to improve science and mathematics curriculum and teaching in public schools. America should learn from existing university and business initiatives as well as from the successes and failures of No Child Left Behind legislation. The Administration and Congress should engage universities, businesses, nonprofit groups, school districts and community organizations in a sustained effort to strengthen the educational choices of children in science and mathematics.

**Universities and Business**

1. Universities should develop better data and analyses concerning their international student populations. They should be better able to track students from admission to jobs. They should improve their capacity to evaluate and describe the benefits and costs of foreign students on specific university priorities such as graduate curriculum and research, patent awards, and faculty and student recruitment. Universities have a strong case to make concerning the negative impact that a

sustained downward trend in foreign student enrollments would have on their quality and on their ability to respond to and strengthen U.S. economic and quality of life objectives. They need to make this case in a loud and clear manner both as individual universities and through their many collegial organizations. Making the case effectively is particularly essential for federal and state legislators who sometimes view the petitions of universities as motivated by self-interest and who wish the universities, particularly public ones, would focus primarily on undergraduate education.

2. Universities and businesses should develop a unique and continuous partnership. Both have much at stake in an increased inflow of international graduate students who wish to study science and engineering in U.S. graduate schools. Both share interests in assuring U.S. national and economic security. Lead organizations representing universities and business should develop and help institute joint marketing strategies. They, and sympathetic foundations, should create a national pool of money for scholarship and fellowship assistance for foreign students. Finally, Universities and businesses should work together to secure increased understanding among political leaders and citizens alike of the link between increased access of international students, scientists and engineers to the U.S. and increased national and economic security.

## Next Steps

Participants agreed that the Forum was unique in that it brought together informed leaders and senior staff from federal and state government, universities and the private sector. Because of this fact, participants wanted a summary report to be prepared and widely distributed describing the proceedings and recommendations of the Forum. As the participants indicated, the report, hopefully, will help foster a dialogue and consensus strategies to convert the U.S. commitment to open its doors to an increased number of international graduate students in science and engineering and international scientists and engineers to reality. This summary report responds to the participants' request. It will be sent to public, business, academic, and community leaders throughout the nation.

Subsequent to the distribution of the report, the conveners of the Forum, the Merage Foundations and the University of California, Irvine, agreed to work together to initiate regional and state meetings to discuss its contents. The meetings will involve participants from the Forum and leaders from public, private, nonprofit and university sectors. The Forum's conveners promised to prepare and circulate periodic status reports concerning the Forum's recommendations and to schedule an annual Forum to measure progress and define next steps.

# Appendix

- **A Canary in the Mineshaft?**
  **International Graduate Enrollments in Science and Engineering in the United States**
  **By Frank D. Bean and Susan K. Brown**

- **International Graduate Students and U.S. Innovation**
  **By Gnanaraj Chellaraj, Keith E. Maskus, and Aaditya Mattoo**

- **International Students and U.S. Policy Choices**
  **By Stuart Anderson**

- **Forum Attendees**

# A Canary in the Mineshaft?

# International Graduate Enrollments in Science and Engineering

# In the United States

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**and**

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This background paper prepared for the Forum by Dr. Frank Bean and Dr. Susan Brown of the University of California, Irvine. Thanks are expressed to Marshall Kaplan and Jeanne Batalova for comments on previous drafts and to Jody Agius, Mark Leach, and Rosaura Tafoya-Estrada for research assistance.

Dr. Frank Bean is professor of sociology at the University of California at Irvine. He is one of the nation's leading immigration scholars with expertise in the following areas: international migration, demography, racial and ethnic relations economic sociology, and the family. His book with Gillian Stevens, *America's Newcomers and the Dynamics of Diversity*, won the American Sociological Association's 2003 Otis Dudley Duncan book award. Dr. Susan Brown is assistant professor of sociology at the University of California at Irvine. Dr. Brown's areas of focus are international migration, educational inequality, and urban sociology.

# A Canary in the Mineshaft?

# International Graduate Enrollments in Science and Engineering In the United States

Technological innovation is arguably the key ingredient for achieving strong economic growth in advanced knowledge-based societies (Freeman 2005). While the specific mechanisms through which new technologies foster growth are strongly debated (Barro and Sala-i-Martin 2003; Lindert 2004), technically based inventions such as wrought iron, steam power, the generation of electricity, and the internal combustion engine have historically generated major economic expansions (Easterlin 1996; Galbraith 1995; 1997). Regardless of whether the invention of the computer and the internet ultimately rank as high in economic significance (Madrick 2002), the fact that many analysts think they will gives weight to the idea that contemporary technology plays a crucial role in international economic competitiveness. It would thus seem self-evident that national science and technology policies would seek to protect and sustain high-technology innovation and capability, for reasons of minimizing risk if nothing else. To take the vitality of technological innovation for granted or to pursue policies that are neglectful invites the possibility of long-term relative economic decline (Prestowitz 2005).

At the moment, the U.S. economy still benefits from technological pre-eminence. But this dominance may be slipping because of global trends in the spread of technology, the force of world population distribution, changes in where scientists and engineers receive graduate training, and relative declines in support for basic research. The first of these, the global diffusion of technology itself, provides a clear example of the need to rethink U.S. strategies regarding graduate education and basic research. As Thomas Friedman (2005) has so incisively noted, the installation, indeed over-installation, of fiber-optic cable around the world during the latter half of the 1990s makes high-speed, low-cost broad-band connectivity available in almost every corner of the world. This "leveling of the playing field" makes possible more than ever before the development and deployment of science and engineering talent and ideas outside the United States.

Developing adequate policies and strategies for sustaining U.S. technological innovation requires understanding the roles a number of factors have played in building U.S. strength. Five are worth noting here. One is an open and flexible immigration system that has allowed talented individuals to come to the United States to study and work. Another is a superb higher educational system that has attracted scientific and engineering (S&E) graduate students and post-doctoral scholars. Another is a high priority on basic research, as well as applied research and product development, an emphasis which has supported graduate-student and post-doctoral research programs. Another is a vital and dynamic U.S. high-tech industry that has converted innovation into useful products, thereby creating demand for highly skilled science and engineering workers. And still another has been the relative global monopoly, at least until recently, of these factors (especially S&E higher education on the one hand and investment in basic research and high-tech product development on the other).

The broad purposes of this paper are to assess inter-relationships among these factors and to gauge their relative importance for sustaining technological leadership on the part of the United States. More specifically, we seek (1) to highlight the importance of high-skilled migration, both permanent and temporary, for the vitality of the U.S. economy in general and for the high-technology science and engineering sector in particular; (2) to point out inter-dependencies between temporary high-skilled migration (involving S&E graduate students and workers on H-1B visas) and high-skilled permanent

migration in order to clarify how and why U.S. immigration policy, along with other factors, carries implications for flows of foreign-born science and engineering graduate students; (3) to examine and explain patterns and trends in the application, admission and enrollment of science and engineering graduate students in the United States; and (4) to assess research and development spending, both in the United States and elsewhere, because the degree of such investment strongly affects both innovation and the likelihood that the world's extremely talented students will continue to study and relocate here. In the concluding section, we note that the growth of higher education and high-tech employment outside the United States, developments that increase world competition for top-flight students and workers (Freeman 2005), may be changing both the dynamics of high-skilled migration to the United States, including graduate-student enrollments, as well as the labor market implications of such migration.

## International Migration and the U.S. Workforce

High-skilled international migrants play a prominent role in the U.S. economy. The foreign-born are just as likely as natives to complete college and more likely to hold advanced degrees, especially in the case of immigrants who have come to the country since 1990 (Hansen 1996; Martin and Midgley 2003). The importance of such immigrants for the economy cannot be captured simply by noting that 13.1 percent of the U.S. population was foreign-born in 2003. Instead, attention must be focused on the adult workforce, where an even larger percentage, 14.4, is foreign-born (U.S. Bureau of the Census 2003) and on young adult workers (those under the age of 45 and thus most likely to be involved in the newer sectors of the economy), where a still higher percentage, 17.2, is foreign-born. Even more dramatic, among highly skilled young workers (with Ph.D. degrees and working in science and engineering), the percentage is a whopping 52.0 percent (Freeman 2005). Such figures illustrate the importance of international migrants in general, and of younger, highly skilled workers in science and engineering in particular, for U.S. economic productivity and growth.

Three main flows of foreign-born persons augment the high-skilled workforce in the United States. The first consists of people who enter via the policy provisions of the regular legal immigration system, namely the employment preference categories. The second consists of temporary non-immigrants who enter with H-1B visas, which run for three years, are renewable once, and are designed for those in high-skilled specialty occupations. A third less direct augmentation consists of international students. Although not initially in the workforce, many of the entrants in this group stay in the country and ultimately contribute to the high-skilled workforce. About one-fourth of these international students are S&E graduate students (National Science Foundation 2004). Also prominent are postdoctoral scholars, many of whom, like the graduate students, stay in the country and thus also contribute to the high-skilled workforce. Even more critically, international S&E graduate students and post-doctoral scholars hold important research positions that are vital to the country's basic research effort. We show below trends in each of these flows and discuss their implications for the nation's workforce and research and development activities.

High-Skilled Legal Immigration

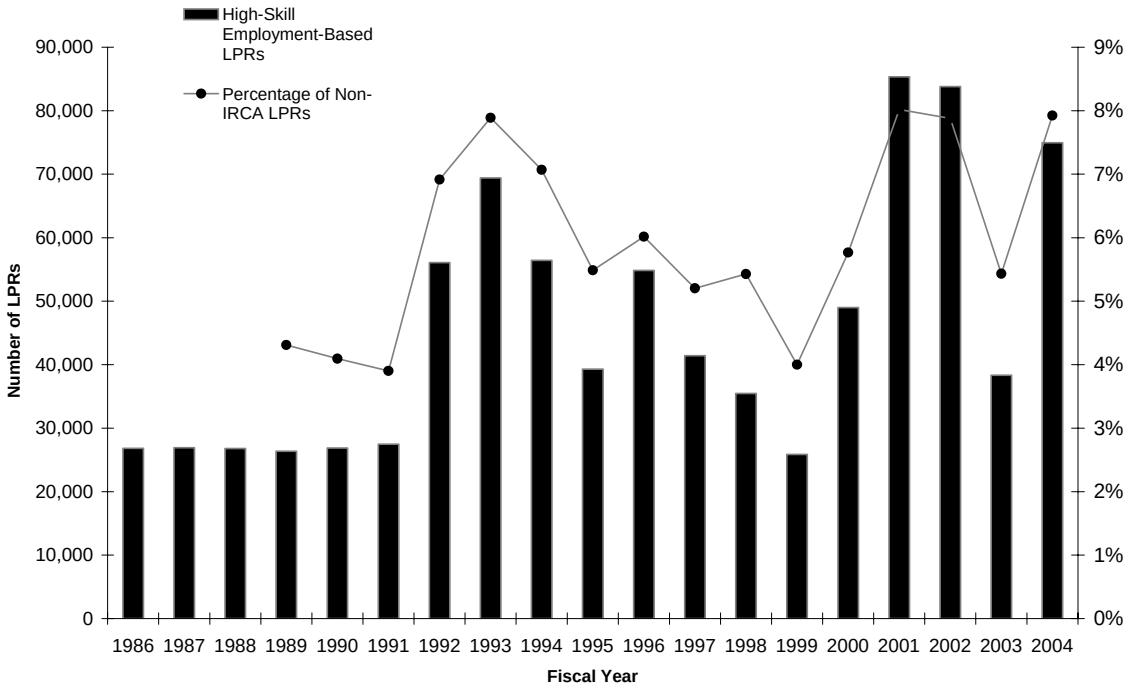
Before 1992, the United States gave considerably more weight to family re-unification than to employment as a basis for granting legal immigrant visas. This was evident not only in the numbers of legal permanent resident (LPR) slots granted under these alternative auspices, but also in the fact that four family-preference categories existed for obtaining legal permanent resident admissions but only two employment-preference categories. Because of concerns in the late 1980s that the U.S. economy needed more high-skilled workers, in 1990 Congress passed the Immigration Act, which President George H. Bush signed in November and which began to affect immigration statistics by fiscal year 1992. This legislation, together with the 1986 Immigration Reform and Control Act (IRCA), constituted the most far-reaching shift in the country's immigration laws since the 1965 amendments to the Immigration and Nationality Act, which abolished national origin quotas as bases for immigrant admission (Bean and Stevens 2003). The main goals of the 1990 legislation were to increase the diversity of the country's immigrants and to allow the entry of greater numbers of skilled workers (Sorensen et al. 1992).

The new employment-based immigration system raised the number of slots available for workers and their families from about 56,000 to 140,000. The law arranged these visas into five categories, which are still in effect. The first consists of priority workers, or persons of extraordinary ability in the sciences and arts. The second consists of professionals with advanced degrees. The third consists of professionals who have a bachelor's degree, and also includes other skilled and some unskilled workers. The fourth consists of special immigrants, such as religious functionaries, and the fifth category consists of investors who will invest at least $1 million, or at least $500,000 in rural or high-unemployment areas. The new law thus opened the door wider to employment-based immigrants and substantially changed the composition of employment-based immigration. Under the first three employment provisions of the new law, more spots were allotted to professionals and skilled workers and fewer to unskilled workers. The latter group, now limited to 10,000, received scarcely half the number it had before 1990 (Fix and Passel 1991).

The numbers of legal permanent residencies granted to high-skilled workers (principals) in each fiscal year since 1985 are shown in Figure 1. The figures under-represent, perhaps substantially, the volume of high-skilled migration to the United States, for at least two reasons. First, the vast majority of U.S. immigrants still enter under the family re-unification categories. Many of these immigrants have high levels of education (Sorensen et al., 1992), although these entrants do not show up in statistics about numbers of high-skilled employment immigrants. Second, the immigration statistics for high-skilled employment LPR's include the spouses and children of principals. However, in order to emphasize principals, Figure 1 excludes spouses and children, even though they constitute about half of all high-skilled LPR's over the past several years. No doubt, many of the spouses also hold advanced degrees and are themselves employed.

**Figure 1**

**High-Skilled Employment-Based Visas, Number by Year and as a Percentage of non-IRCA Visas**




Souce: Office of Immigration Statistics, Table 24 of Yearbook of Immigration Statistics: 2004 Temporary Admissions (Nonimmigrants)
http://uscis.gov/graphics/shared/statistics/yearbook/yrbk04ta.htm

By showing the overall numbers of employment-sponsored immigrants (those in the first three categories) in particular fiscal years, not the numbers of persons newly admitted to the country in those years, Figure 1 also misrepresents when the immigrants first came to the country. In fact, well over 80 percent of each of the fiscal year totals involves persons who had adjusted their statuses. In 2004, for example, 87.5 percent of the principals in the first three employment preferences and their spouses were "adjusters" rather than "new arrivals" (U.S. Citizenship and Immigration Service 2005). Most of these were changes from student or H-1B temporary worker visas (or even sometimes from unauthorized status, which itself usually results from overstaying either a student or H-1B visa). Thus, the figures for the most part involve high-skilled people who had already been in the country under student or H-1B visas. This is one of the chief reasons it is important to examine trends in all three of these kinds of admissions taken together.

Student or H-1B visas are thus perhaps the chief pathways by which high-skilled foreign-born persons enter the U.S. immigration system and ultimately gain legal permanent residency (Usdansky and Espenshade 2001). The possibility of obtaining legal permanent residency status on the basis of education and skills provides an incentive for foreign-born persons to come to the United States as graduate students and H-1B workers, illustrating what is often an interdependency between temporary and permanent forms of entry to the country. What many observers may not realize, however, is that a ceiling on permanent high-skilled slots creates a squeeze whenever greater numbers of temporary entrants seek permanent status than the ceiling can accommodate. Such squeezes are almost inevitable because in recent years Congress has been far more likely to increase temporary slots than to raise the ceiling on permanent slots (Lowell 2001).

The big upswing in the numbers of high-skilled, employment-based legal permanent residents after the 1990 Immigration Act is evident in the yearly totals in Figure 1, although levels jump around somewhat from year to year, partly because lag times in the processing of applications vary from year to year. In any event, by the 2000s, around 70,000 high-skilled principals each year were receiving employment-sponsored legal status, a figure that constituted about 8 percent of the total number of legal immigrants coming to the country outside the special legalization provisions of the 1986 Immigration Reform and Control Act (IRCA).[1] If we compare only principals, the percentage of high-skilled employment-based principals of all principals would be even higher, about 16.0 percent. And if the data were available to include in the category of high-skilled principals those family-based principals with high levels of education who are also employed, the percentage of principals with high levels of education would be greater still, perhaps reaching 20-25 percent.

The relatively high levels of high-skilled immigration during the early 2000s after the economic boom of the late 1990s reveal the sometimes problematic feature of the cap on employment-based permanent immigration (the slight fluctuations in the numbers in Figure 1 after 2000 may be more a reflection of application processing variations than of changes in either the demand for such workers or the demand for such visas among potential immigrants. The high levels thus mean that demand in those years probably continues to outstrip supply (Lowell 2001), even in a relatively stagnant economy (except perhaps in 2003, which may represent a delayed manifestation of the dampening effects of 9/11 on interest in adjusting to legal permanent resident status). But because under current law, the number of employment-based legal permanent residents cannot change, and because many high-skilled employment immigrants have previously held either student or H-1B visas, and because the latter especially is growing enormously (as we show below), the demand for high-skilled employment-based legal status appears recently to have been outrunning supply. The important point here is to note this may be troublesome in the near future, especially if the business cycle swings upward.

Temporary High-skilled Migrants

Because many of the employment-sponsored slots are granted to persons who have previously held H-1B temporary visas, it is instructive to examine trends in the numbers of such visas granted. The 1990 Immigration Act defined skills for the first time on the basis of education (Usdansky and Espenshade 2001: 34-37). In addition to increasing substantially the number of employment-based slots (allowing them to almost triple to 140,000 by 1992), and raising the number of employment-based preferences from two to five, the law introduced a special category of high skilled-temporary worker through its adoption of the H-1B visa for non-immigrants. The number of such visas was set at 65,000 annually. H-1B workers were to be paid the prevailing wage for their job and were permitted to stay three years (renewable for another three years). Also, no cap was set for their spouses and minor children, unlike the case of regular employment-based visas (Usdansky and Espenshade 2001). For example, for H-1B visas, the 65,000 ceiling applies to principals, but by the time spouses and children are included, this generates many more than 65,000 entrants, whereas the 140,000 ceiling for permanent employment visas, which includes principals and spouses and children, generates only about 70,000 principals annually. A new development as of May, 2005, is that 20,000 more H-1B visas will be issued to foreign students who completed a graduate program in the American universities (these visas will NOT be included in the 65,000 visa cap).

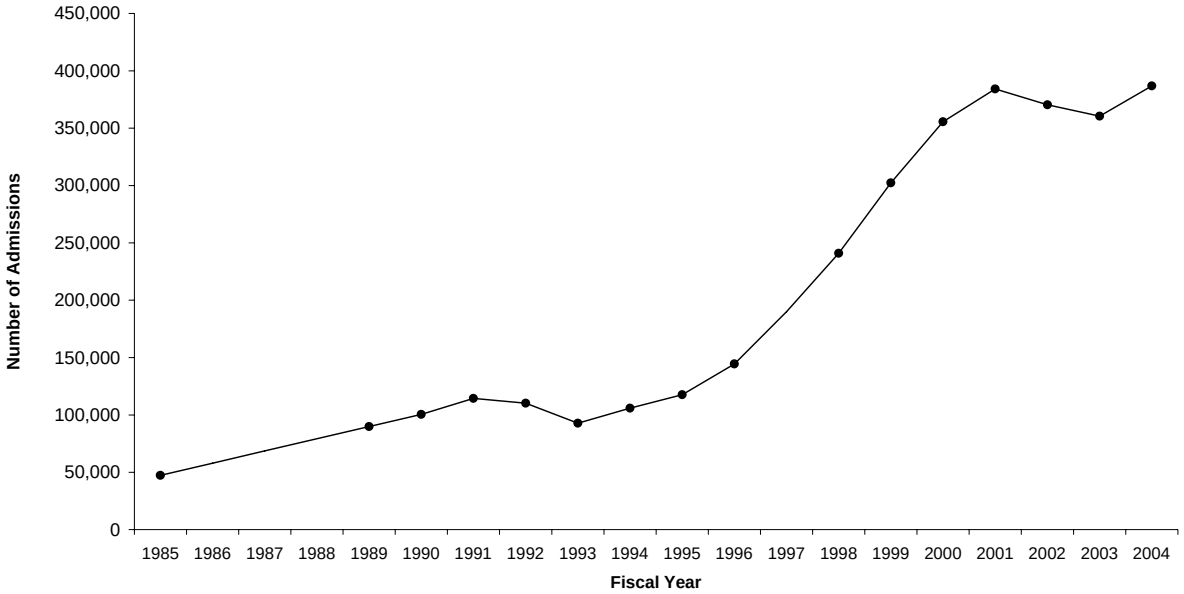
The impetus for the 1990 legislative changes was a growing concern during the late 1980s about looming shortages of high-skill and specialty workers, fears that were fueled by think-tank and government studies like the Hudson Institute's "Workforce 2000" report and the 1990 Report of the Council of Economic Advisors predicting that high-skilled labor squeezes were likely soon to develop (U.S. Congress

1991). In 1997, for the first time, the 65,000 ceiling on H-1B visas set in 1990 proved insufficient to meet demand. Up until then the number of such visas had not been an issue, but after that point, there were pressures to increase the ceiling. In response, Congress in 1998 raised the number to 115,000 visas for 1999 and 2000. But in fiscal year 1999 the new supply of H-1B visas still ran out by June, with the result that in October of 2000 Congress rushed to extend the limit to 195,000 for an additional three-year period.

The strong growth in the number of H-1B admissions began in the mid-1990s (Figure 2). Interestingly, its initial trend was counter-cyclical with that of high-skilled employment-sponsored immigrants. That is, as the number of H-1B admissions went up during the late 1990s, the number of high-skilled employment immigrants went down, reflecting in the early stages of the H-1B expansion a substitution of temporary workers for legal permanent resident workers (Lowell 2001). However, by the early 2000s, the rising levels of temporary H-1B workers undoubtedly were creating greater demand for legal permanent resident status as H-1B recipients confronted the expiration dates of their three-year stays. This trend is likely only to grow. Time and time again, in place after place around the world, temporary migration programs have begotten permanent migration (Cornelius, Martin and Tsuda 2003). It is thus no shock that the same pattern seems to be emerging with high-skilled migration to the United States. Current limits on high-skilled *permanent* immigration may be too low to meet the needs of the economy. If so, it would not be at all surprising to see growing *unauthorized* migration of the high-skilled in the next few years.

**Figure 2**

**Number of H1B Admissions by Year**




Source: Office of Immigration Statistics, Table 24 of Yearbook of Immigration Statistics: Nonimmigrants Admitted by Class of Admission: Selected Fiscal Years 1981-2004. http://uscis.gov/graphics/shared/statistics/yearbook/2004/table4.xls

## Graduate-Student Enrollments in Science and Engineering

Given the importance of science and technology in the global economy and the importance of international migration among the highly skilled, trends in international enrollment of science and

engineering students are of particular interest, especially since graduates who remain in the United States to work comprise a major source of high-skilled foreign-born workers. Trends in enrollments are also important because of the tightening of entry requirements for foreign-born students after 9/11and the greater subsequent difficulty in obtaining visas. We seek here to address a number of important questions about these trends. First, to what extent does the available evidence indicate that the enrollment of science and engineering graduate students in the country has recently declined? Second, to what extent does any observed decline result from science and engineering students being unable to acquire appropriate visas because security requirements were tightened in the wake of 9/11? Third, to what extent does any observed decline derive from factors other than difficulties in obtaining visas? Fourth, to what extent have changes in the enrollment of foreign and of native-born S&E graduate students tended to move counter-cyclically with one another? Or, stated differently, do native enrollments decline when foreign enrollments increase, and vice versa, suggesting competition between these groups for graduate slots? Or does the available evidence indicate other kinds of labor market forces drive trends in enrollment?

It is important to emphasize that it is difficult at this point to answer these questions definitively based on evidence obtained from analytical studies because of limited data. For example, information collected on the visa status of graduate students (even in some very rough sense) did not distinguish first-time from continuing students until 2001, meaning that only a very short time series of information about first-time enrollments is now available, even though this information is crucial for discerning the influence of current conditions on enrollment trends. Moreover, some of the relevant data are still not available for recent years. For example, even though preliminary information on applications and admissions are available for 2004 and 2005, enrollment data for 2005 are not yet available (Brown and Doulis 2005). And information on graduate international enrollments that disaggregates graduate student visa holders by gender into temporary and more permanent residents is available only up through 2003, meaning that a gender-specific time series of only two years can be examined after 9/11 (National Science Foundation 2004). Despite such limitations, it is nonetheless possible to discern important clues, both from the patterns involved in the trends and from the results of other research studies, about the forces driving recent graduate student enrollment trends. This helps to answer the above four questions, at least in a preliminary way. We address each of the four below, after first describing the changes in graduate student enrollments over the past decade or so.

Changes in International Graduate Student Enrollments

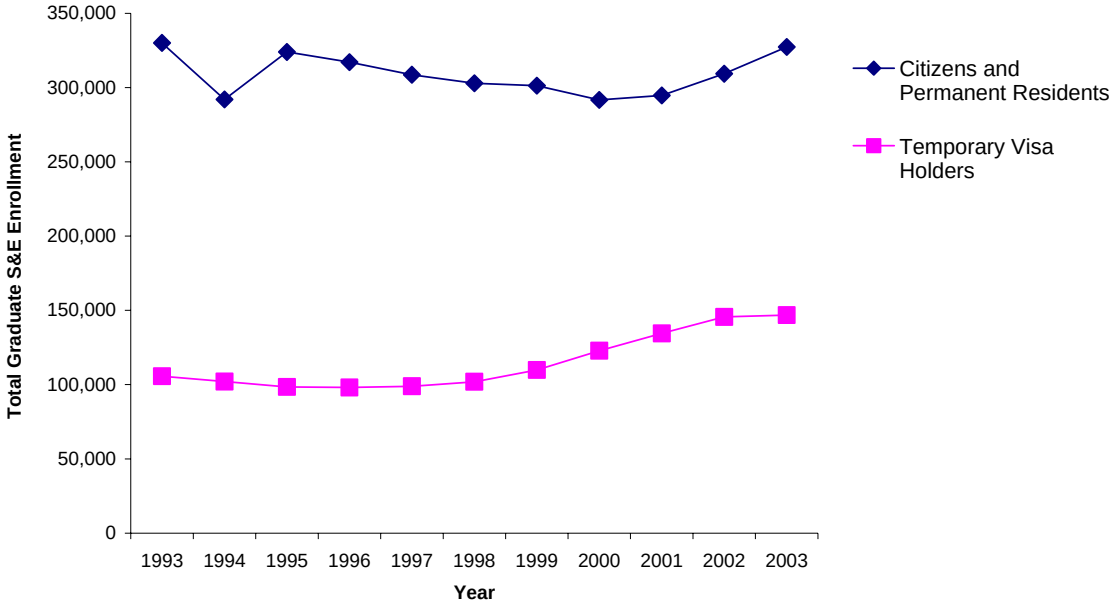
The numbers of foreign-born students in the United States began to increase after World War II. By 1954, 34,232 (or 1.4 percent) of higher education enrollments were international students on temporary visas. This, of course is a conservative estimate of foreign-born students because immigrants who had become legal permanent residents would not be counted as international students. In short, the percentage of foreign-born enrollments was undoubtedly even higher than this figure indicates. By 2002, international enrollments had grown to 613,221 (or 4.1 percent) of the total, a conservative figure given that by the early 2000s, about 18,000 students each year were converting their status from that of student visa to legal permanent resident (U.S. Citizenship and Immigration Services 2005).

While many international undergraduate students may eventually change their status and stay in the United States, it is graduate students, especially those in science and engineering, that are immediately and more directly involved in U.S. research and development endeavors through their participation in university research projects. Figures 3 and 4 show the trends since 1992 in both total and first-year graduate student enrollments in the United States for two categories of students – citizens and permanent residents on the on hand and temporary residents on the other. 2003 is the last year as of this writing for which we have data broken down by citizenship, temporary visa status, first-time enrollment, and gender. For that year, at least 150,000 graduate students were in the country on temporary visas (an apparently unknown number of permanent residents and naturalized citizens were also here, but these two different kinds of students cannot be examined separately because the National Science Foundation's statistical reports lump these

together with native citizens). Foreign-born graduate S&E enrollment has risen by about 50 percent since 1996 and continues to increase, and foreign-born science and engineering graduate students now make up almost a quarter of all foreign-born student enrollments in the United States (including undergraduate enrollments), and nearly half of all science and engineering graduate enrollments. This rise is characteristic of both men and women (Figure 5). As many observers have noted, international graduate enrollments have become an ever larger and more integral part of the nation's research and development (R&D) programs (Freeman 2005; National Research Council 2005).

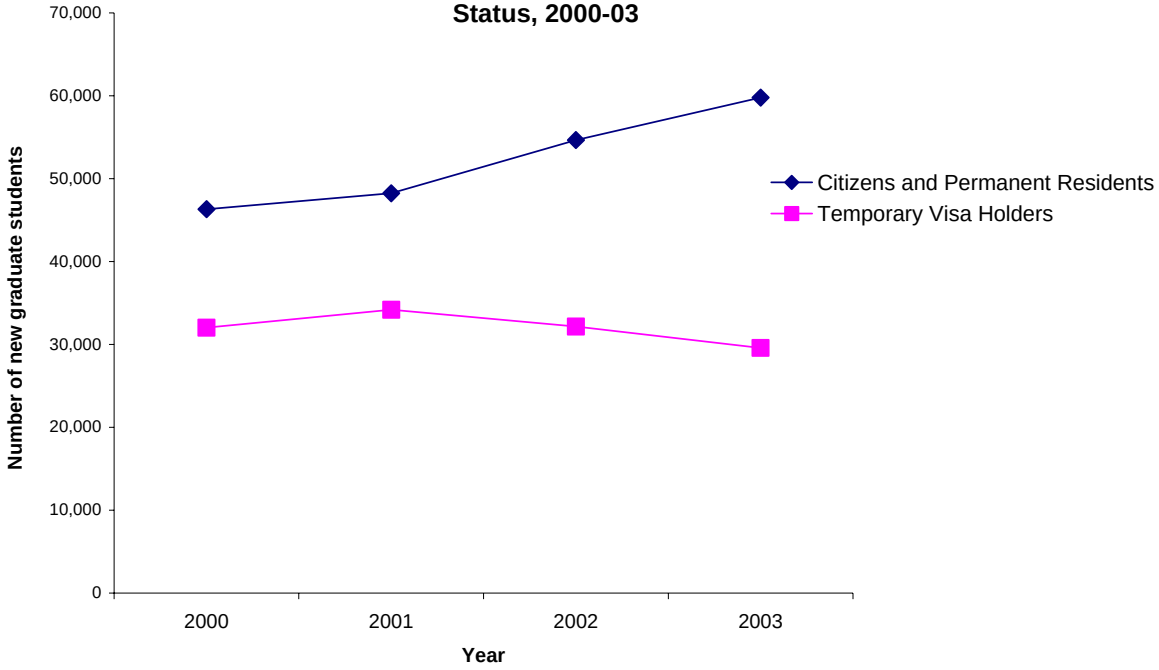
**Figure 3**

**Graduate Enrollment in Science and Engineering, by Citizenship and Visa Status, 1993-2003**




Source: National Science Foundation, Division of Science Resources Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering.

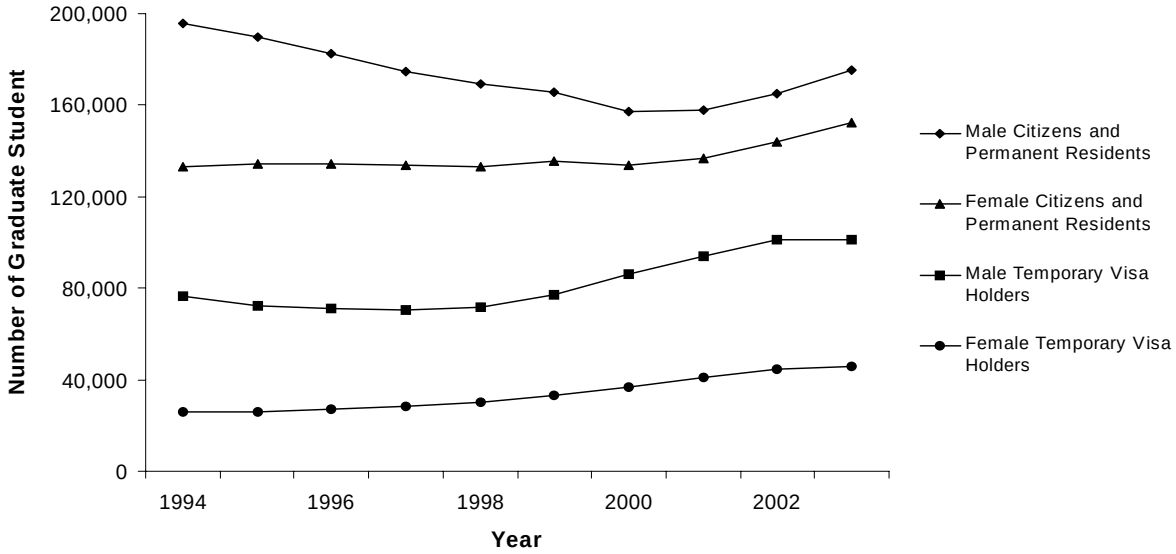
**Figure 4**
**Enrollment of First-Time S&E Graduate Students, by Citizenship and Visa Status, 2000-03**




Source: National Science Foundation, Division of Science Resources Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering.

**Figure 5**

**Graduate S&E Enrollment by Gender, 1994-2003**




Source: National Science Foundation, Division of Science Resources Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering.

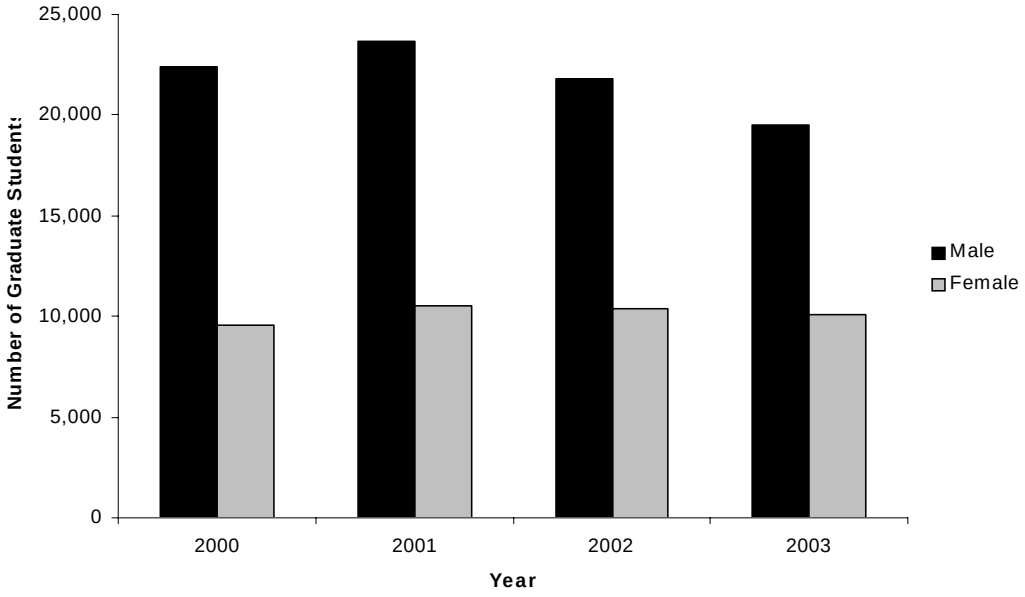
Have There Been Declines after 9/11 due to Changed Visa Review Procedures?

Since 2000, the National Science Foundation (NSF) has also been reporting information on first-time enrollments of foreign graduate students. These first-time data are more sensitive to the influence of contemporaneous events like 9/11 than total enrollments, since students already enrolled in long-term programs would be less affected by such occurrences or the policy shifts they spawn. Figure 6 shows the first-time S&E enrollments for both permanent and temporary students. The results reveal three important patterns. First, the very narrow gap in 2000 between temporary (foreign-born) and permanent/citizen (mostly native-born) first-time graduate student enrollments suggests that by the end of the 1990s foreign-born graduate students constituted an even larger fraction of the total number of science and engineering enrollments (about 40 percent) than previously, demonstrating how rapidly the foreign-born have increasingly become a larger share and more integral part of S&E enrollments and R&D in the country.

Second, and most important, the results show that enrollments declined after 2001 for first-time, foreign-born graduate S&E students, showing a drop of 4,605 students, or a decline of 13.5 percent, by 2003. Third, and significantly, this decrease does not represent a broader, more general pattern since it does not characterize permanent resident/citizen (mostly native-born) first-time enrollees. In other words, the decline shows up only among foreign-born first-time enrollees, suggesting a significant negative impact from the more arduous and often intimidating visa screening after 9/11. The National Research Council (2005) recently reached this conclusion as a result of a thorough investigation of graduate enrollment trends.

**Figure 6**

**First-Time S&E Graduate Students with Temporary Visas by Gender, 2000-2003**




Source: National Science Foundation, Division of Science Resources Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering.

Although the enrollment data from the National Science Foundation (NSF) stop for now at 2003, other sources suggest that the decline in international graduate students in science and engineering continued at least through 2004. Annual percentage changes in science and engineering applications, admissions, and enrollments reported by the Council of Graduate Schools (CGS) (Brown and Syverson 2004; Brown and Doulis 2005) show overall international graduate student applications down nearly 30

percent from 2003-2004, and those for S&E international graduate students over 35 percent for the same years (Figures 7 and 8). Smaller declines occurred in admissions and enrollments. Applications for 2005, however, declined only slightly, and overall admissions and enrollments were up slightly from the previous year. However, from 2004 to 2005 small declines continued for admissions and enrollments of new international S&E graduate students.

Because most students apply to and may be admitted by more than one school, and because the least committed students may be the ones most discouraged from applying, the greater decreases in applications and admissions do not necessarily represent proportionate decreases in yield, or enrollments, as the figures in fact make clear. The National Research Council (2005) study also concluded that no clear evidence has yet emerged of a decrease in the quality of international S&E graduate students enrolling after 9/11. But as far as *overall* S&E graduate student enrollments are concerned, a decline clearly occurred post-9/11, and changes in visa review procedures seem definitely to have been responsible for a substantial portion of the drop, at least in the first two years after 2001. Moreover, the decrease has not yet bounced back to pre-9/11 levels, despite the substantial reduction in the time required to process visa applications and the lengthening of the student visa period from one to four years.

**Figure 7**

**Changes in Applications, Admissions and Enrollment of New International Graduate Students, 2003-05**

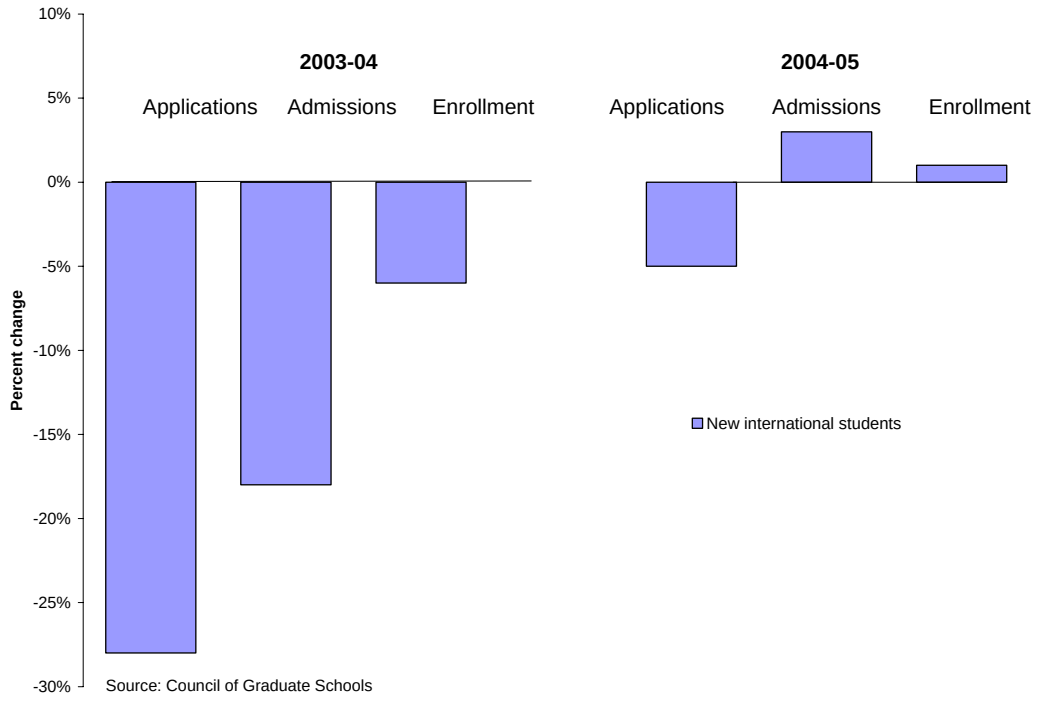
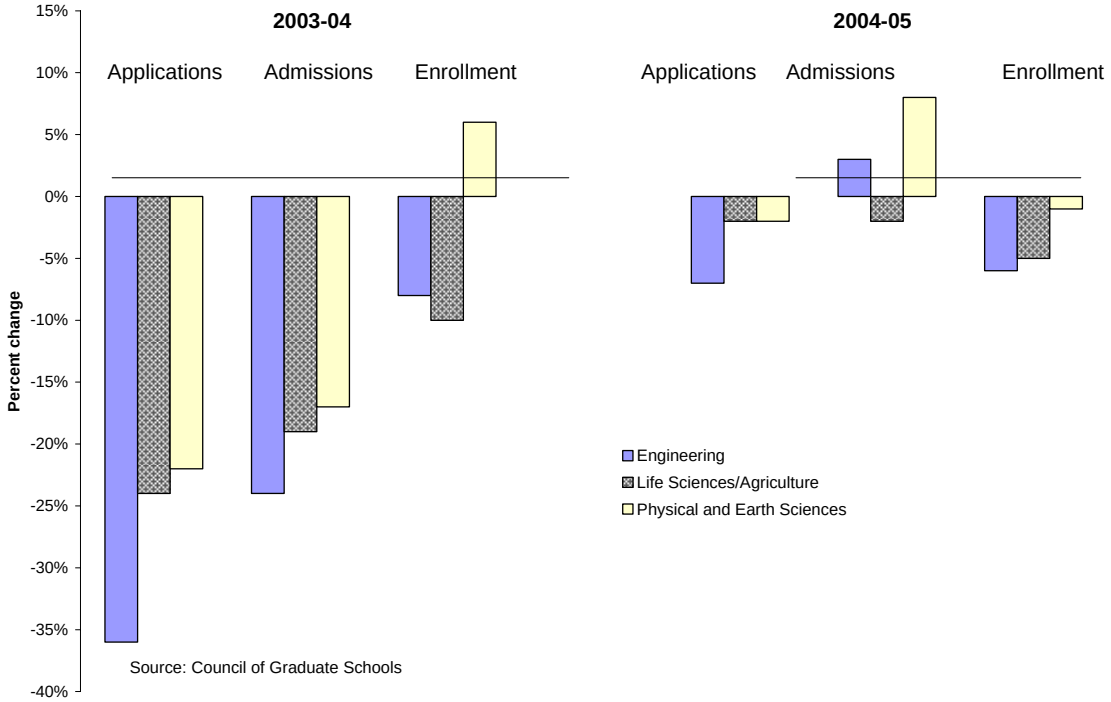


**Figure 8**

**Changes in Applications, Admissions and Enrollment of New International Graduate Students in Science and Engineering, 2003-05**




Are Other Factors also Contributing to the Decline?

Other factors thus may be contributing to the continuing retardation of foreign S&E graduate enrollments, even after the substantial improvements have taken place in the visa processing situation for international graduate students. The CGS data in Figures 7 and 8 suggest such additional forces may indeed be at work. A small decline in applications occurs from 2004 to 2005, even after the new visa processing changes were implemented. Moreover, an enrollment decline also shows up in the NSF data among foreign-born women, who had previously been moving upward in their share of first-time foreign enrollments. Also, widespread reports of recently increased opportunities for graduate S&E education in Britain, the European Economic Union (EEU), Australia, India and China suggest a greater global presence of alternatives for S&E graduate study than used to be the case (The Economist Intelligence Unit 2004).

Analysts have also noted the rise in international opportunities for graduate S&E education outside the United States started before 9/11 and has grown steadily since then (Brown and Doulis 2005). What may be new, however, is the attractiveness of these opportunities after the negative experiences many visa applicants underwent after 9/11. These may have led to the development of negative perceptions about the United States, with this in turn contributing to a boost in the demand among prospective foreign-born S&E graduate students for the pursuit of graduate studies in locales other than the United States. In short, just as other countries have started to strengthen their supply of graduate S&E educational opportunities, their attractiveness may have received an unanticipated boost from the new security practices by the United States, perhaps along with other aspects of U.S. foreign policy that have been unpopular abroad. At the moment, however, we lack clear evidence over the past two or three years that foreign-born S&E graduate students are opting in large numbers not to come to the United States, but this possibility must be given serious consideration.

Is There Evidence of Competition Between Foreign and Native S&E Graduate Students?

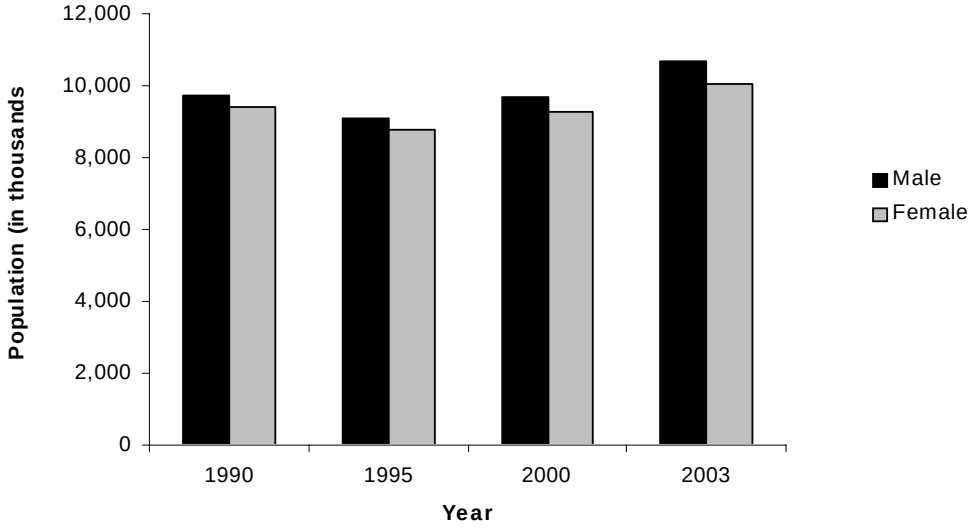
Concerns have also been expressed that natives, especially males, are increasingly less likely to enroll in science and engineering graduate programs because of increased competition from the foreign-born for research assistantships and fellowships (Borjas 2004). From 1993 to 2000 the number of U.S. citizen and permanent resident male graduate students decreased while the number of temporary international graduate student males increased (National Science Foundation 2004), as indicated by the trends shown in Figure 5. At first glance, the opposite directions of these trends would seem consistent with the possibility that foreign students may have "crowded out" natives. However, after 2000 native male enrollments rose at the same time as overall international male enrollments, a result inconsistent with the competition hypothesis. To be sure, *first-time* international male enrollments fell, but the fact that this drop owed at least in substantial measure to visa difficulties, as noted above, again does not suggest crowding effects. Rather, the results suggest the earlier enrollment decline among natives (as well as the recent increase) may have stemmed from factors other than competition from foreign students.

In fact, one factor that may help explain the recent native male upturn is growth the past few years in the size of U.S. birth cohorts becoming eligible for entry into graduate study. Figure 9 shows that, from 1995 to 2000, and then again from 2000 to 2003, increases occurred in the sizes of these age cohorts of 20-24 year olds, the primary age range for graduate school entry. This implies that recent native trends may be affected by fluctuations in cohort size related to changes in U.S. demographic factors like earlier fertility behavior, rather than merely from nativity competition. Moreover, native female enrollments held steady during the 1990s even in the face of simultaneous foreign-born female enrollment increases, a pattern again not consistent with the competition argument. Also, both foreign and native-born groups of females increased their enrollments from 2000 to 2003 (Oliver 2005), a trend that again does not suggest a crowding effect.

Beyond the influence of changes in demography, other circumstances like the strength of the S&E job market, the nature of S&E working conditions, and the relative availability of attractive alternatives (i.e., high-paying and jobs with good working conditions) also influence native graduate student enrollments. This is particularly true among native males, whose labor supply appears more sensitive to U.S. labor market conditions than that of international males.

**Figure 9**

**US. Population Ages 20-24, 1990-2003**




Source: U.S. Census Bureau, Statistical Abstract of the United States: 2004-2005; and Population Paper Listings PPL-41.

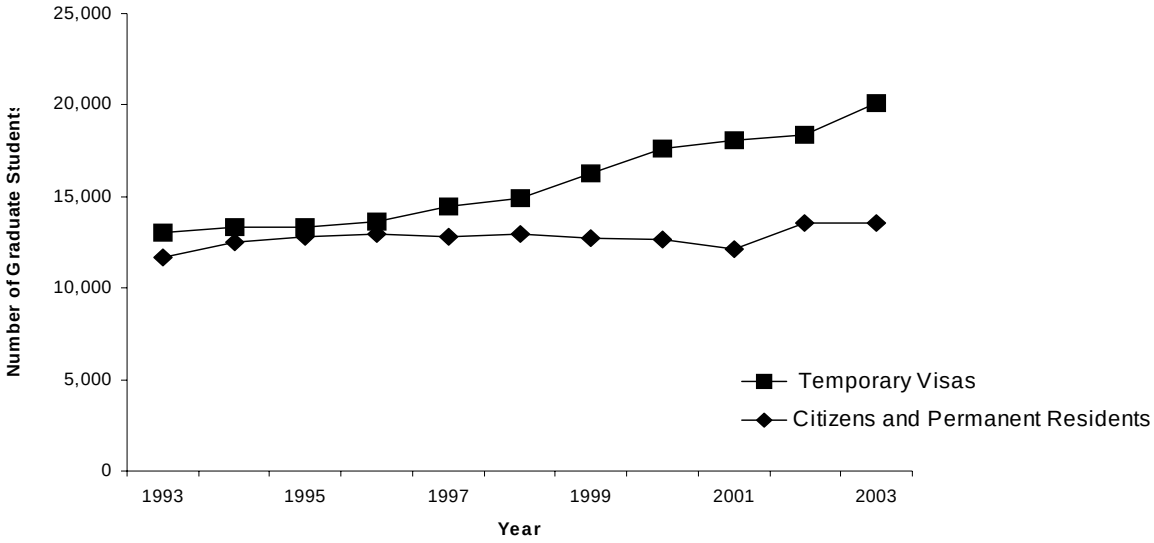
Freeman (2005) has convincingly shown that during the 1990s pay levels in S&E deteriorated even as training requirements (length of graduate study and/or post-doctoral apprenticeship) became more onerous. But the U.S. research and development community has been able to cope with this handicap by relying even more heavily on foreign-born S&E talent than before. In other words, native graduate enrollments seem likely to have declined not because research projects were competitively substituting foreign-born talent for native-born talent, but because a significant portion of the native-born talent pool pursued more attractive alternative careers.

Post-doctoral Scholars

If the foreign born represent a large and growing share of science and engineering enrollments in the United States, they constitute an even larger (and also increasing) share of post-doctoral students in the country. Figure 10 shows the trends since 1992 in post-doctoral enrollments. Again, the lines represent temporary (foreign) and permanent (most likely native) numbers. Even in 1993 the foreign-born occupied slightly more than half of all post-doctoral positions in science and engineering, and the gap has only widened since then, reaching nearly two-thirds of all science and engineering post-doctoral positions by 2003. Interestingly, the number of temporary visa holders has only climbed since post-9/11, possibly because many of the post-doctoral scholars were graduate students in the United States and thus already held visas. As with graduate students, the growing gap between numbers of foreign and native post-doctoral scholars seems likely to have more to do with the long periods of time many scholars have to remain in post-doctoral positions and their stagnating rates of pay, even in health-related fields (Brainard 2005).

**Figure 10**

**Postdoctoral Scholars in Science and Engineering, 1993-2003**

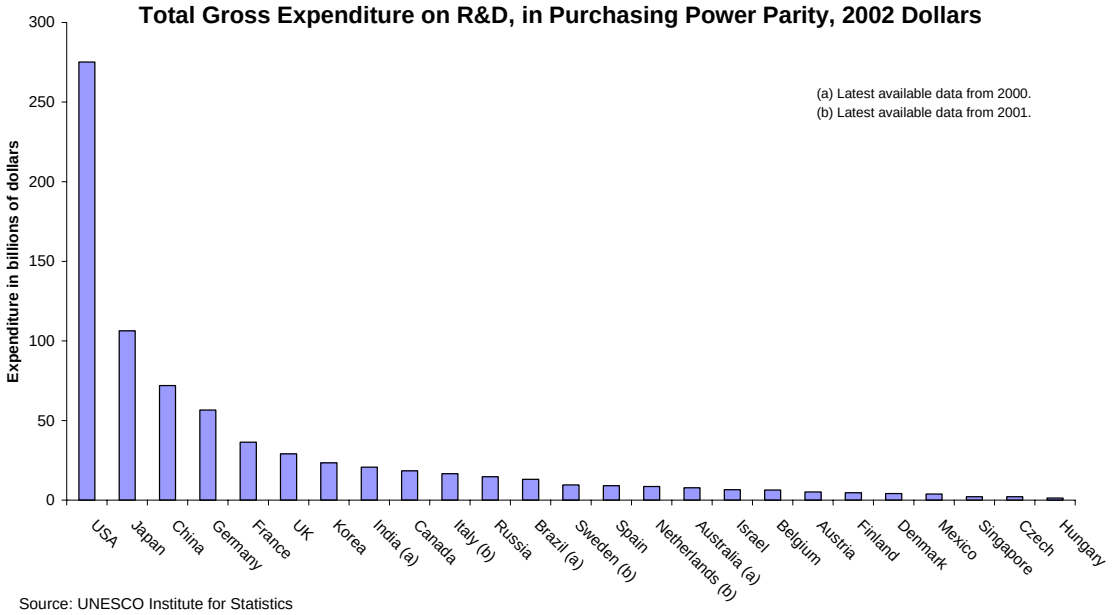



Source: National Science Foundation, Division of Science Resources Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering.

## The Investment in Research and Development

Because most of the nation's basic research is conducted in universities and because international graduate students and postdoctoral scholars constitute such a large part of science and engineering graduate enrollments and research, international students are vital to this country's research and development efforts (Fossum et al. 2004). The United States competes with other countries for top-flight talent to work on this research, and within the United States, S&E fields compete with other industries and occupations for the best students. Success in attracting both foreign and native-born talent clearly depends both on the numbers of research assistant and post-doctoral positions available and on the pay scales associated with such study and work. Since at least World War II, the United States has enjoyed a pre-eminent position in the world with respect to the total volume of spending on research and development. As Figure 11 reveals, no other country even comes close to the total gross expenditures on R&D as the United States. In 2002, the second largest expenditure (in purchasing power parity dollars) was Japan, whose level of slightly more than $100 billion was only about 40 percent of the U.S. total (UNESCO 2004).

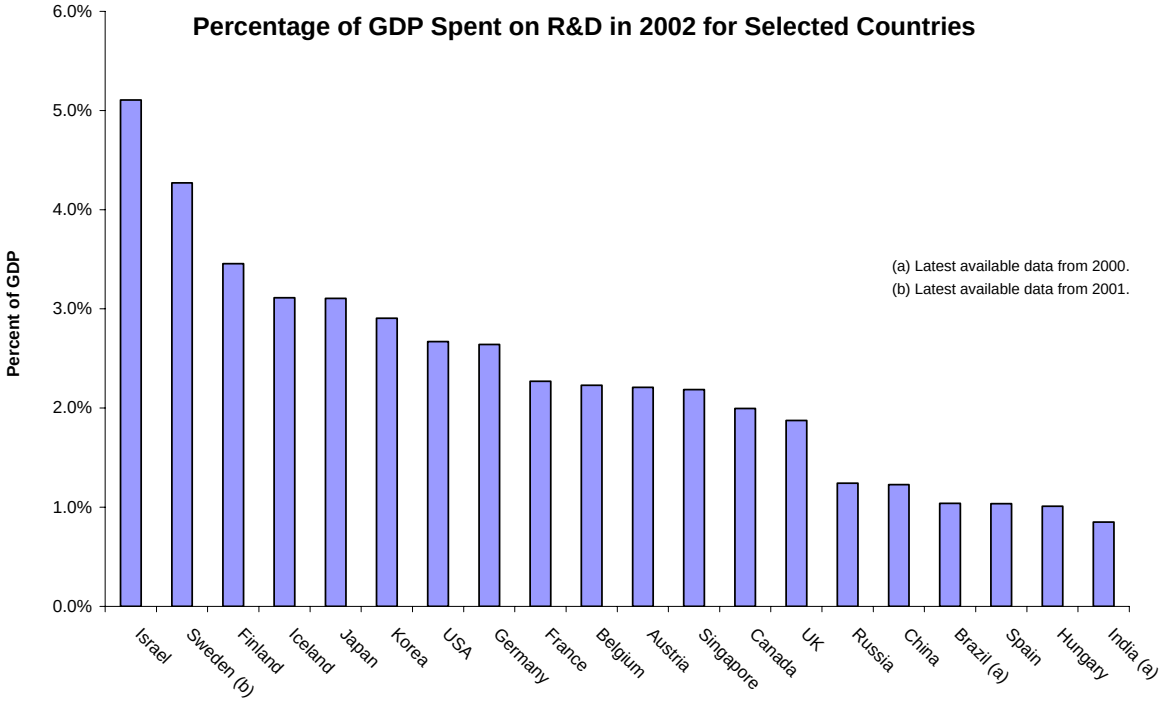
**Figure 11**




Source: UNESCO Institute for Statistics

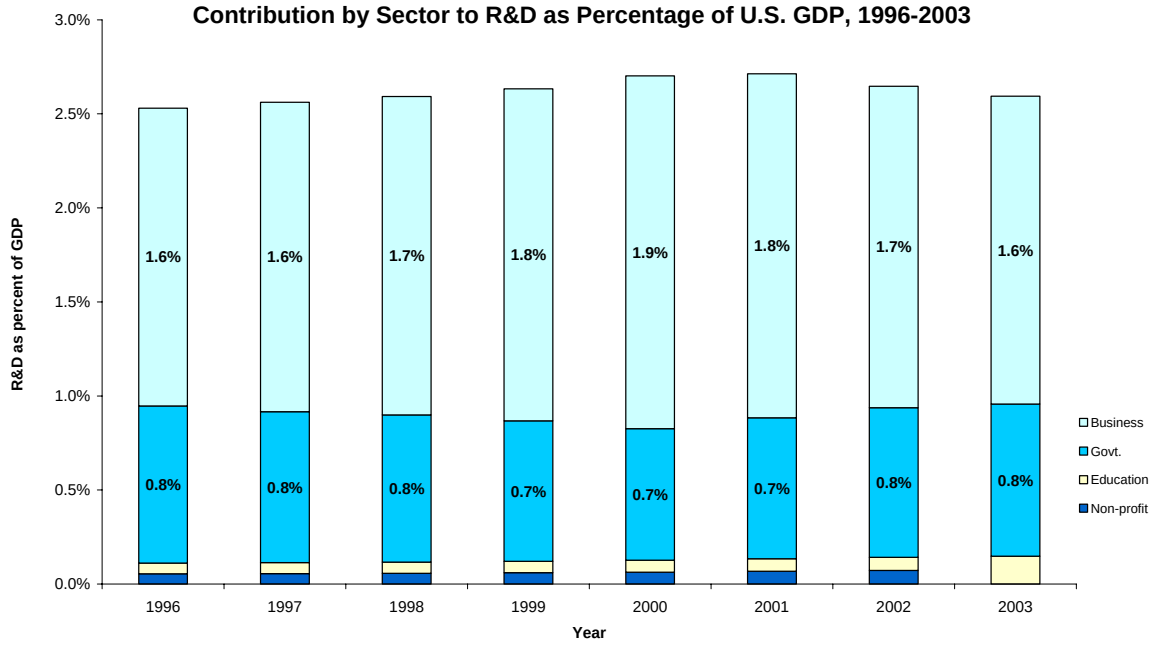
Clearly much of the U.S. superiority derives from the enormous size of the U.S. economy. However, when examined in relative terms, the United States does not fare so well. As Figure 12 reveals, when R&D investment is expressed as a percentage of gross domestic product, the United States ranks no better than 7$^{th}$ in the world in the priority devoted to investment in research and development. Moreover, the trend in relative investment in R&D in the country has turned downward since 2001, dropping 8.1 percent (see Figure 13). The increased emphasis given to R&D by other countries is clearly discernible in the data in Figure 14, which show increases in such relative investment since 1996. The United States has scarcely changed at all during this period, and has actually declined since 2001, with the result that the country's share of global R&D investment has fallen from 39.6 to 36.4 percent since the mid-1990s (UNESCO 2004).

## Figure 12




Source: UNESCO Institute for Statistics

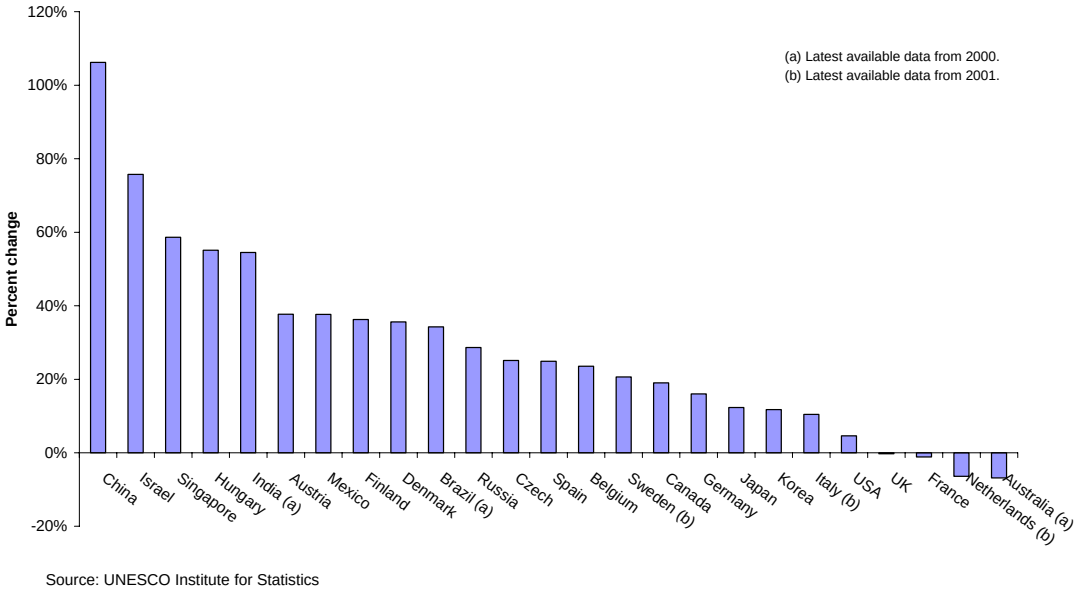
## Figure 13




Source: UNESCO Institute for Statistics; Bureau of Economic Analysis, U.S. Department of Commerce

**Figure 14**

**Change from 1996-2002 in Percent of GDP Spent on R&D, Selected Countries**

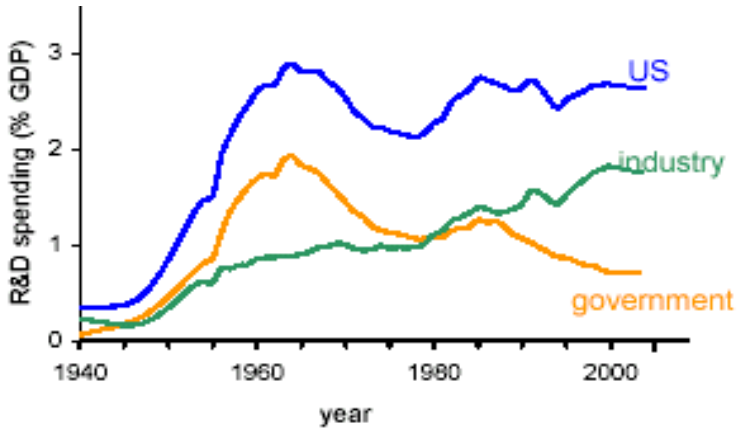



Source: UNESCO Institute for Statistics

Moreover, the effects of the decline in relative R&D spending in the United States are likely even more dramatic than the statistics suggest, for two reasons. The first is that the long-term trends are down in particular for government spending as opposed to industry spending (Figure 15). This matters because the government is much more likely than industry to support spending on basic research, the kind of investment that appears to have constituted the main well-spring of innovation in the American economy for the last sixty years (Fossum et al 2004; Freeman 2005; The Economist Intelligence Unit 2004). Industry spending is much more likely targeted at applied problems, or finding new ways better to convert innovation into viable products, rather than innovation per se (President's Council of Advisors on Science and Technology 2002). The relative decline in basic research expenditures is thus even more severe than the numbers on both research and development taken together indicate. Second, the overall relative stagnation in R&D in general, and the decline in government basic research spending in particular, would have been far worse except for major increases in life science research spending over the past ten years. Specifically, the research budgets of the National Institutes of Health approximately doubled from 1995-2004 in constant dollars (Brainard and Field 2005; Freeman 2005), a rise that serves to mask the declines and stagnation in other kinds of government basic research investment (Figure 16).

**Figure 15**

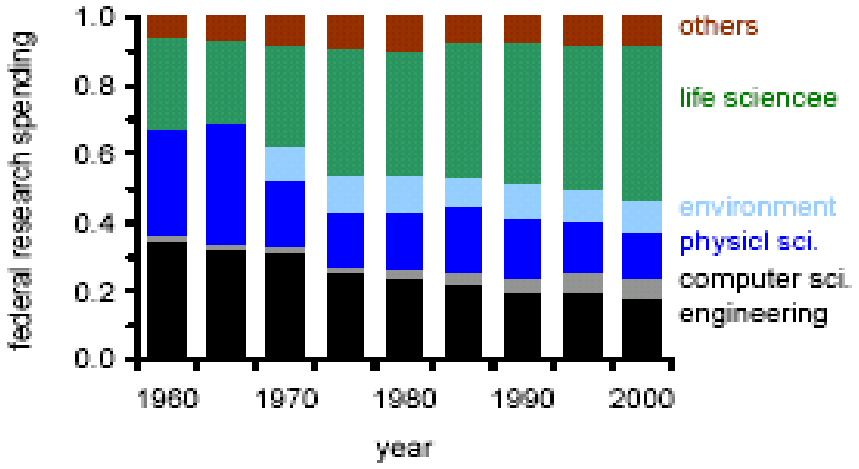
**Research and Development as a Percentage of GDP by Sector in the U.S., 1940-2003**




Sources: On-line supplement to Auyang, Sunny. 2004. *Engineering – an endless frontier* . Cambridge, MA: Harvard University Press. http://www.creatingtechnology.org/R&D.htm. Data from 2001-2003 from UNESCO Institute for Statistics and U.S. Department of Commerce, Bureau of Economic Analysis.

**Figure 16**

**Federal Research Spending by Sector in U.S., 1940-2000**




Source: On-line supplement to Auyang, Sunny. 2004. Engineering – an endless frontier. Cambridge, MA: Harvard University Press. http://www.creatingtechnology.org/R&D.htm.

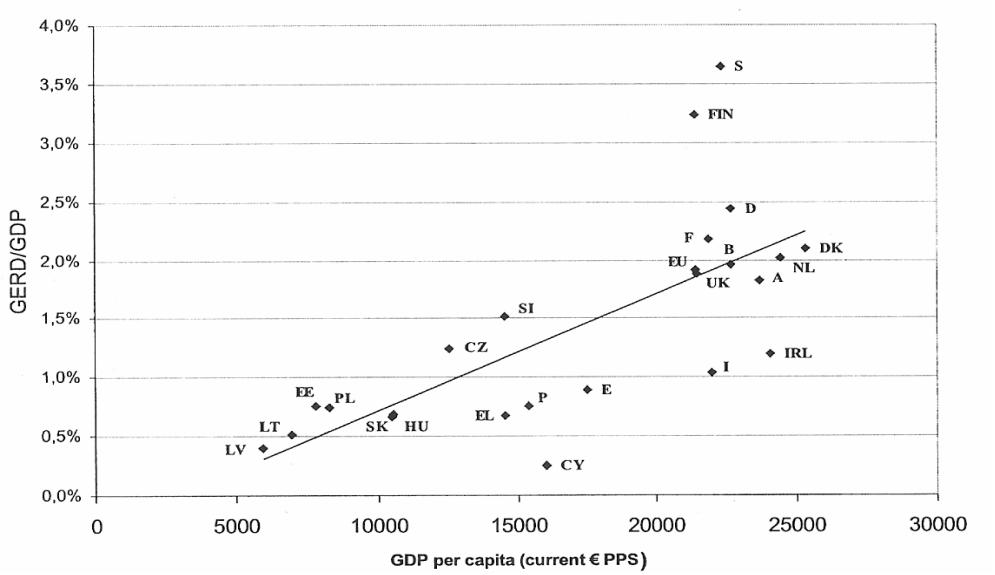
The past ten years or so have thus witnessed a significant relative drop in almost all categories of U.S. investment in basic research. This decline ranges from basic defense-related spending under the auspices of DARPA (Defense Advanced Research Project Agency) to physical science, computer science and engineering basic research spending under the auspices of the NSF (Kling 2005; Fossum et al 2004; Markoff 2005).

To be sure, the research budgets of the United States are still higher than those of other countries in terms of the absolute levels of dollars, but the relative priority the country has given to research and development over the past several years, and within that category to basic research in particular, is noticeably less than it was in the not too distant past.

Does investment in R&D make a difference for the economy? As Richard B. Freeman (2005: 1), the distinguished Harvard labor economist, puts it: "Leadership in science and technology gives the US its comparative advantage in the global economy. US exports are disproportionately from sectors that rely extensive on scientific and engineering workers and that embody the newest technologies. In 2003, with a massive national trade deficit, the smallest deficit relative to output was in high technology industries…. In a knowledge-based economy, leadership in science and technology contributes substantially to economic success." The relationship between science and technology leadership and economic dynamism is reflected in the positive association between per capita gross domestic product and the relative investment in research and development. This association is shown in Figure 17 for the countries of the European Economic Union. Some may think there is an ambiguity about the direction of causality in this relation, about whether it is rich countries that can afford to invest in R&D, or whether it is relatively high R&D countries that become rich. But even if it were the case that only rich countries could afford R&D, not the other way around, this would beg the question of what helps countries become rich in the first place and what now sustains high economic growth in increasingly global and ever more knowledge-based economies.

**Figure 17**

**Federal Research Spending by Sector in U.S., 1940-2000**




Source: Commission of the European Communities. 2003. "Investing in Research: An Action Plan for Europe." Commission staff working paper. Brussels. http://europa.eu.int/comm/research/era/3pct/index_en.html

The positive implications of basic research investment for economic growth result from innovations that potentially contribute to increased productivity (Kortum 1997; Kortum and Lerner 2000; President's Council of Advisors on Science and Technology 2004). Recent research shows that the notable increase in U.S. patent applications and grants over the past 15 years was driven largely by knowledge transfers from academic science (Branstetter and Ogura 2005).

In particular, most of the increase in the number of patents occurred in the bio-nexus and was found to have been generated by spill-overs from basic biological research. Interestingly, and perhaps not

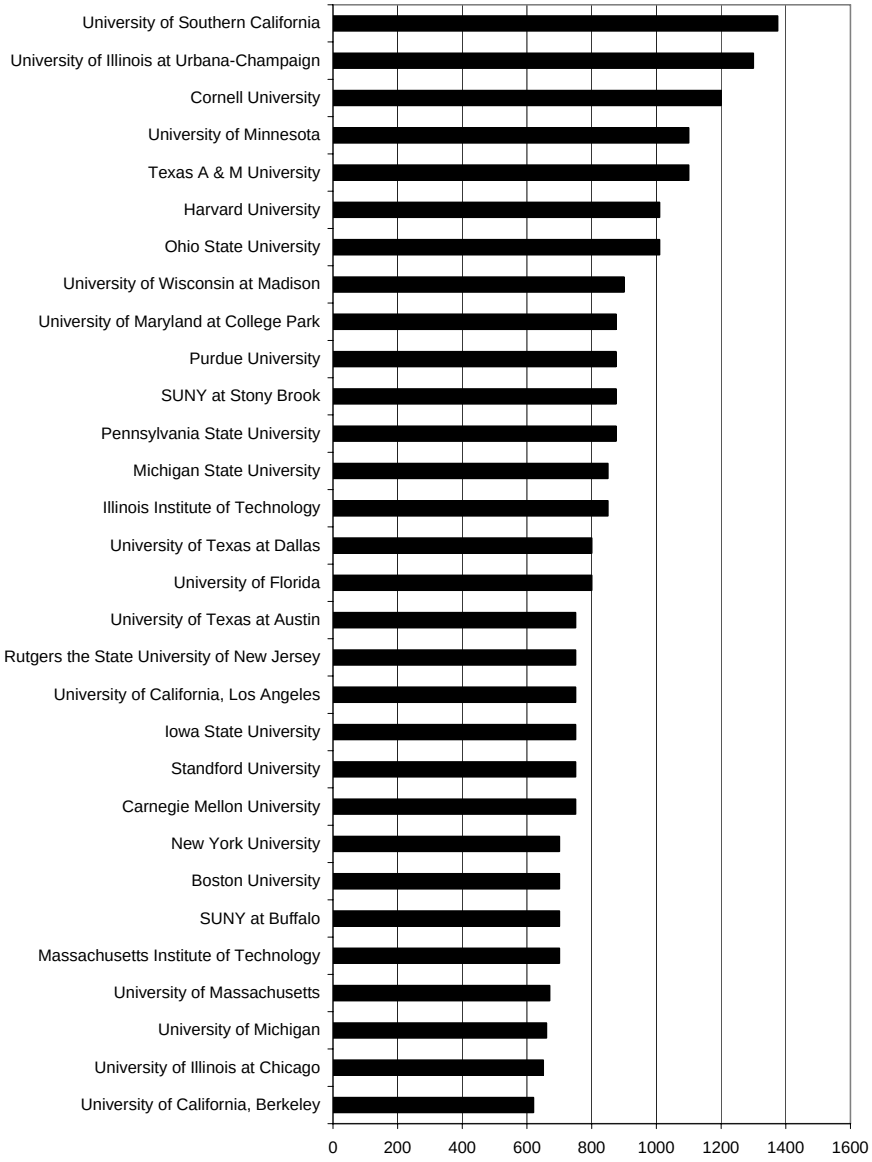
coincidentally, the life sciences are the one area in which major federal budget cuts for basic research have *not* been implemented in recent years, as noted above. Yet since 2003, research expenditures at even the NIH have been relatively stagnant in real dollar terms after several years of increases.

If the United States has faltered in its support for basic research funding except in the health sciences, a question arises about the degree to which the private sector has absorbed the slack. Even though increases in industrial development spending may have partially offset government cutbacks, they have not been sufficient over the past three years to cause R&D investment to rise as a percentage of GDP. This stagnation must thus be absorbed in academic science, which in engineering especially often means in public universities, whose budgets have been squeezed at the state level over the past five years even as federal research funds have fallen (Hebel 2005; Ehrenberg 2005). Most of the foreign-born science and engineering graduate students and post-docs in the country enroll in public universities (Figures 18 and 19). That the private universities do not, with three or four exceptions, meet much of the country's need for science and engineering instruction and research is striking. And, of course, even private universities depend substantially on government financing for basic research, in some ways even more than public universities (Fossum et al 2004). Further declines in the availability of basic research funds in science and engineering thus seem likely to lead to further decreases in foreign graduate students and post-doctoral scholars in S&E research in the country.

The likelihood that a drop in foreign enrollments will be made up by increases in native enrollments seems slim, given that low levels of pay, the lengthy apprenticeships of graduate students and post-docs in these fields, and the availability of attractive alternative careers discourage natives, especially males (Freeman 2005). Moreover, the increases that have occurred among natives the past three years are not likely to last given that they are probably driven more by a weak economy and by demographic change (transitory increases in cohort size) than by anything representing the beginnings of long-term upswings. And further increases in graduate S&E enrollments among women and minorities are not likely to be sufficient to compensate for even moderately large decreases in international enrollments. These factors all suggest the United States in the near future may be unable to rely as much as it has in the recent past on international graduate students and post-doctoral scholars for S&E basic research.

**Figure 18**

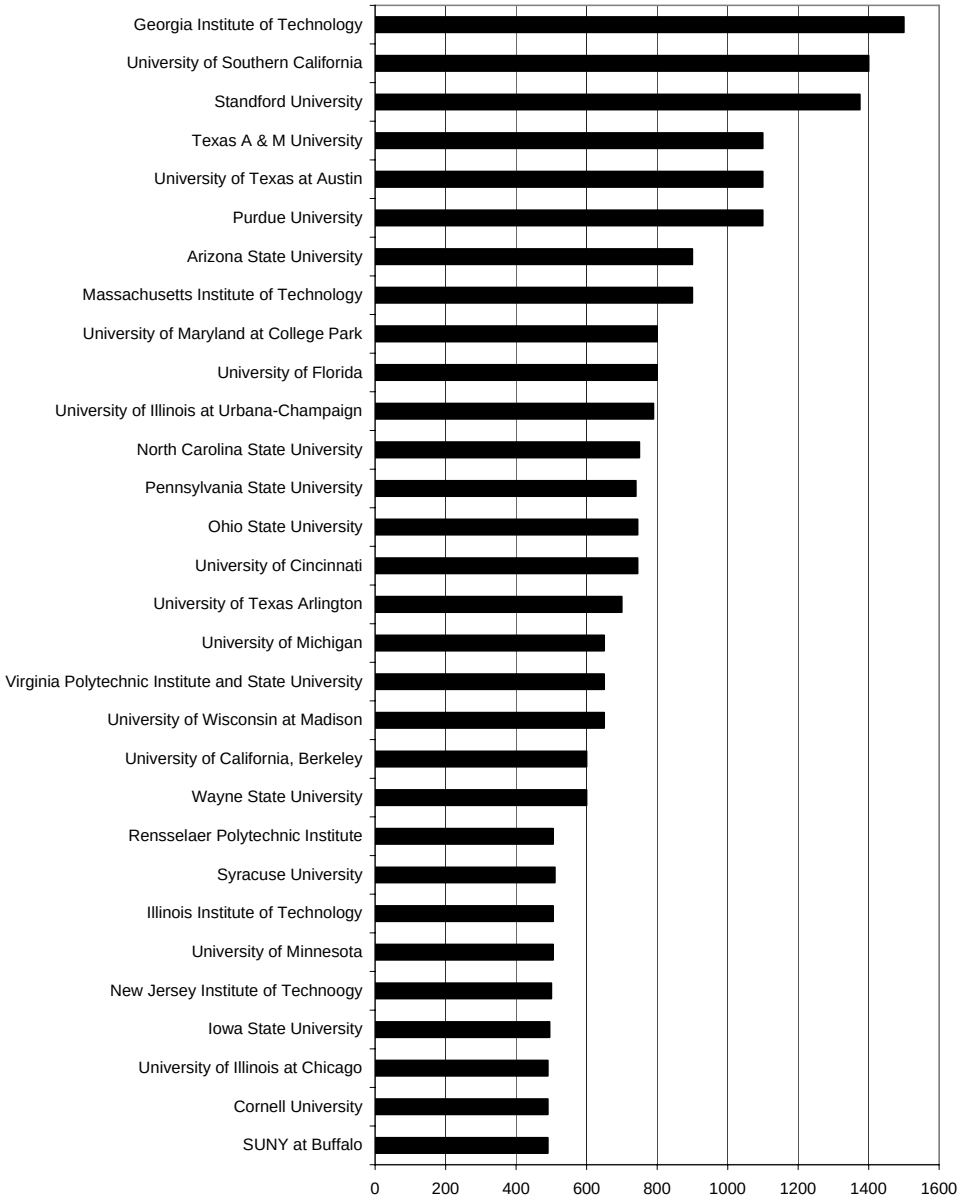
**Institutions with the Largest Number of Science Graduate Students on Temporary Visas, 2001**




Adapted from Figure 1-6 of Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States

**Figure 19**

**Institutions with the Largest Number of Engineering Graduate Students on Temporary Visas, 2001**




Adapted from Figure 1-5 of Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States

# Conclusions

This paper has focused on the examination of recent trends in the enrollment of science and engineering graduate students and post-doctoral scholars in the United States. These occur in a context of a low ceiling on the numbers of legal high-skilled employment visas. Declines over the past three years in first-time graduate student enrollees appear to result substantially from changes in visa application procedures and time delays involved in security checks. However, the fact that such enrollments have not yet bounced back to their earlier levels, even though major visa processing improvements have been made, suggests that the recent enrollment decline probably does not derive from 9/11 problems alone (although some of it undoubtedly does). A portion, perhaps even a large part, may stem from recently increases in opportunities elsewhere in the world for graduate science and engineering study and employment and from the United States becoming less relatively attractive as a destination. Ironically, the changes behind such developments have occurred at about the same time as, or perhaps even a bit before, 9/11, meaning that the data emerging in the aftermath of 2001 may have obscured some of the other reasons for the drop in foreign-student involvement in the important U.S. R&D sector.

Unless decreases in graduate S&E enrollment prove short-lived, they carry enormous implications for the country's research and development programs. Some observers may be tempted to note the up-tick in native enrollments the past few years and conclude that the native upswing after 9/11 may continue and go a long way to solving any shortages that might develop in the future. This conclusion would be premature at best, because changes in native enrollments may be primarily the result of demographic changes generating growth in the size of native cohorts of 20-24 year olds and upswings in the availability of attractive employment alternatives for natives. This means the recent native increases are not permanent, because they are likely soon to turn into declines when these factors change, unless women and minorities enter science and engineering in far greater numbers than they have before. The recent drops in international enrollments, together with what are likely to be further declines in native enrollments, thus become critical concerns. Ironically, they may be exacerbated by decreases in relative U.S. spending on basic research. The United States faces the challenge, particularly in a difficult fiscal environment, of avoiding negative spirals by which declines in basic research spending beget declines in international graduate S&E enrollments, which in turn beget further declines in the country’s basic research infrastructure. Clearly, such possibilities need examination with steps taken to shore up not only the country's graduate S&E enrollments, including its foreign enrollments, but also its investment in basic research (President’s Council of Advisors on Science and Technology 2002).

The conclusion that buttressing the nation's basic research infrastructure requires high priority attention is reinforced by the evidence that foreign-born scientists and engineers do not appear to be crowding natives out of science and engineering activities. More likely, the native trends downward in the 1990s derived from smaller cohorts of potential students and more desirable employment alternatives, particularly for white males. Foreign students have filled the vacuum, drawn to the country by its strength in innovation and technology. But this attractiveness may now be diminished somewhat. Alternatives for graduate S&E study and R&D employment are increasingly available elsewhere and other circumstances (bad visa application experiences and distaste for U.S. policies) may have tarnished the image of the country. At the same time, the relatively poor pay and unappealing working conditions for science and engineering graduate students in the United States continue. The danger for the future is not merely that talented natives may continue to find alternative careers quite appealing, but that talented foreigners for the first time will be drawn to their own newly available alternatives elsewhere for S&E education and R&D employment. In short, neither immigrants nor natives may be very attracted to U.S. science and engineering graduate study and careers unless circumstances change.

Improving basic science and engineering research funding, including taking the step of increasing pay levels for graduate students and post-doctoral scholars, might at least serve to keep these vital activities attractive to foreign students, and perhaps bring back more natives as well. If the country is to continue to

lead the advanced economies of the world in the way that it has in the recent past, it's a safe bet that either foreign or native S&E graduate students will be needed, or both.

## Endnote

[1] The 1986 Immigration Reform and Control Act (IRCA) included provisions allowing unauthorized migrants to legalize, that is, to become legal permanent residents, one year after obtaining temporary legal status. IRCA-based applicants for legal immigrant visas began entering the U.S. immigration system in substantial numbers starting in 1989, and their flow tapered off after 1992. We exclude IRCA immigrant visas because they came about through entirely different mechanisms than other immigrant visas.

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# International Graduate Students and U.S. Innovation

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This paper was abstracted from an earlier manuscript titled "The Contribution of Skilled Immigration and International Graduate Students to U.S. Innovation," University of Colorado Working Paper, 2004. It was provided as background to Forum participants. The Paper's authors are Gnanaraj Chellaraj, Keith E. Maskus and Aaditya Mattoo.

Gnanaraj Chellaraj was a Consultant to the World Bank when research was undertaken for this paper. Keith E. Maskus is the Chairman, Department of Economics, University of Colorado at Boulder and Aaditya Mattoo is a Lead Economist at the World Bank's Development Economics Group. The opinions expressed in this paper are those of the authors and do not in any way reflect the views of the University of Colorado or the World Bank.

## 1. Introduction

Since the advent of far-tighter restrictions on the issuance of U.S. education visas in the wake of the attacks of September 11, 2001 immigration policy for foreign graduate students has become the subject of

intense debate. Those who are concerned about the policy shift claim that it will harm the nation's innovation capacity. For example, American university officials are increasingly concerned that these restrictions could cause "…a crisis in research and scholarship…"[42] The same point finds its way into editorials.[43] Lawrence Summers, president of Harvard, warned the U.S. State Department that the decline in foreign students threatens the quality of research coming from U.S. universities,[44] although this claim has been disputed by a prominent analyst (Borjas, 2002, 2004).

If limits and delays in the number of foreign graduate students in science and engineering and, more generally, of foreign skilled workers has the long-term impact of limiting innovation, productivity would suffer. Recent evidence indicates that productivity growth in the United States has been generated largely by advances in technology (Basu et al., 2001; Basu, et al, 2003; Gordon, 2004a, 2004b). Technological improvements largely have been driven by the rate of innovation, which has been increasing in recent years as measured by the rapidly growing number of patents awarded to U.S. industries and universities (Kortum, 1997; Hall, 2004).

The United States remains at the cutting edge of technology despite frequent complaints about quality deficiencies in its secondary education system.[45] Indeed, among the major developed countries and the newly industrialized countries, the United States ranks near the bottom in mathematics and science achievement among eighth graders.[46] What may reconcile these factors is that the United States attracts large numbers of skilled immigrants that enter directly into such technical fields as medicine, engineering, and software design (Gordon, 2004c). Moreover, the education gap is filled by well-trained international graduate students and skilled immigrants from such countries as India, China, Korea, and Singapore (the last two of which rank at the top in mathematics and science achievement). Certainly the United States sustains a significant net export position in the graduate training of scientists, engineers, and other technical personnel.

It is likely that international graduate students and skilled immigrants are important inputs into the U.S. capacity for continued innovation, but this basic hypothesis surprisingly has not been formally tested. In this paper we estimate an innovation production function in which graduate students and skilled immigrants are an input into the development of new ideas, both at universities and in the private sector. The econometric model permits productivity differentiation between domestic and foreign graduate students and domestic and foreign skilled workers in producing patents awarded to universities and private businesses.

Results of the econometric analysis indicate that, holding constant the presence of total graduate students and the cumulative number of doctorates in science and engineering, increases in the presence of foreign graduate students have a positive and significant impact on future U.S. patent applications and grants awarded to both firms and universities. This finding extends to the relative presence of skilled immigrants in the labor force, with an increase in the skilled immigrant share significantly raising later patent awards in both types of institutions. Put simply, we find that both enrollment of foreign graduate students and immigration of skilled workers have a strong and positive impact on the development of ideas in the United States.

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[42] Recently a letter to this effect was published by a broad coalition of US academics representing 25 organizations and 95 individuals. See "Academics Warn of Crisis over Visa Curbs", *Financial Times* May 16, 2004.
[43] "Visas and Science: Short-Sighted," *The Economist*, May 8, 2004.
"Security Restrictions Lead Foreign Students to Snub US Universities," *Nature*, September 15, 2004.
[44] *Financial Times*, April 28, 2004.
[45] See, for example, National Governors Association, "The High School Crisis and America's Economic Competitiveness to be Discussed," 29 September 2003, at http://www.nga.org/nga/newsRoom/1,1169,C_PRESS_RELEASE%5ED_5948,00.html
[46] For comparison with other countries see the results of the Trends in International Mathematics and Science Study (TIMMS) at http://timss.bc.edu/timss2003.html.

## 2. Background

The question of whether skilled and other forms of immigration bring net benefits is much discussed in media and policy circles in rich countries.[47] It is even the subject of negative, and rather polemical, pieces by well known scholars (Borjas, 2002, 2004; Huntington, 2004). It is evident that a major component of such gains must be the contribution of skilled immigrants and students to an economy's capacity to innovate and raise productivity. As noted earlier, the question has not been the subject of systematic empirical analysis. However, there are related strands of literature that help motivate our analysis.

### 2a. Basic Economic Models

Labor economists have focused on the static implications of immigration into the United States for domestic wage inequality and prices (Briggs 1996). It is evident that inflows of unskilled workers, which have been a rising share of U.S. immigrants in recent decades, could reduce the wages of domestic unskilled labor and contribute to rising wage inequality (Clark, et al, 2002).[48]

Davis and Weinstein (2002) argued that a single-factor Ricardian model could be used to analyze the implications of factor inflows into the United States. Aggregating labor and capital into a single factor, they calculated simply that such inflows implied a loss of some $72 billion per year for US natives relative to a free-trade baseline without immigration. The reason is that the incoming factors contribute to production capacities without expanding per-worker productivity, leading to significant losses on the terms of trade and lower real wages.

In our view this analysis is misleading because it fails to account for at least two important issues. First, in a broader static model immigrants can raise the productivity and real wages of native skilled workers. Second, and more relevant for our analysis, is the possibility that skilled migrants may generate dynamic gains through increasing innovation. Indeed, the expansion of the market associated with greater factors would itself motivate the development of new goods. Such innovation could contribute to future productivity gains of native workers, resulting in a net increase in real wages. Put differently, in a dynamic context immigration of skilled workers would be complementary to local skills, rather than substitutes for them. Thus, more realistic theory suggests that skilled migration would support rising aggregate real incomes in the long run.[49] Ultimately, the impacts of immigration on real incomes through innovation are an empirical issue.

Indeed, pessimistic claims about the impacts of foreign workers seem inconsistent with continued political support, arising from the high-technology sectors, in the United States for sustaining immigration of skilled workers and engineering and science students.[50] Thus, an essential motivation for our paper is to investigate whether this support is rooted in the dynamic innovation impacts of such foreign workers studying and residing in the United States.

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[47] See, for example, "The Politics of Immigration: Business v. Bush," *The Economist*, October 18-24, 2003, pp. 29-30, and "German Immigration: Brains Not Welcome Here," *The Economist*, May 1-7, 2004, p. 50.

[48] In fact, Borjas, et al (1997) found that immigration into the United States during 1980-95 accounted for about 25 to 50 percent of the decline in the relative wage of high-school dropouts. They suggested that unskilled immigration had relatively little positive impact on skilled-labor wages.

[49] See also Chander and Thangavelu (2004), who show in a theoretical model that permitting high-skilled immigration plus offering education subsidies is sufficient to ensure new technology adoption.

[50] See "The Politics of Immigration" above note 6.

2b. Foreign Graduate Students and Skilled Immigration

The issue of international students and their contribution to host-country economies has been addressed only recently although students have been leaving their home countries for study abroad for nearly four thousand years (Cohen, 2001). Until World War II, a substantial proportion of international students studied in Europe, but this began to change after 1945. Most pronounced was the dramatic shift by Asian students since 1985 toward study in the United States.

To put the U.S. situation into context, note that annual flows of skilled immigrants rose by a factor of more than 30 in the period 1960-2000, while those of international students rose by a factor of 8.2.[51] An important impetus was the Hart-Cellar Immigration Act of 1965, which removed the National Origins quotas established by the Johnson-Reid Immigration Act of 1924, and resulted in greater flows of skilled immigration and foreign students. These trends were accelerated after passage of the Kennedy-Rodino Immigration Act of 1990. Studies by Cobb-Clark (1998), Clark, et al (2002) and Antecol et al. (2003) indicate that legislative reforms resulted in a sharp increase in the flow of highly talented international workers into the United States. Further, there is an important relationship between human capital investment and immigration (Duleep and Regets, 1999).

Data demonstrate further that the number of skilled immigrants as a proportion of the U.S. labor force increased sharply after 1965, and especially after 1990, while foreign graduate students as a percentage of total graduate students went up rapidly after 1975. It is worth noting that foreign graduate students have a high propensity to remain within the United States, at least for the early proportion of their careers, and those who are educated in the United States earn higher wages (Bratsberg and Ragan, 2005; Schoeni, 1997). Aslanbeigui and Montecinos (1998) found that 45 percent of international students from developing countries planned to enter the U.S. labor market for a time and 15 percent planned to stay permanently. Another 15 percent planned to go to a third country. Despite attempts by the U.S. Congress to forbid employment of international students after graduation since the early 1980s,[52] and in some cases restrict the flow of international students to domestic universities,[53] the United States still allows a significant proportion to stay and work after graduation and in a majority of cases even grants them permanent residence. Thus, graduate training of foreign students may have long-lasting impacts on innovation capacities.

On a negative note, Borjas (2002) speculates that foreign students in the United States benefit the economy to the tune of $1 billion a year, but this gain is more than offset by the costs of taxpayer-financed grants and subsidies at public universities. In another paper Borjas (2004) finds a strong negative correlation between the enrollment of native men in U.S. graduate programs and the enrollment of foreign students. Institutions which experienced the largest increase in foreign enrollment were also institutions that experienced the steepest fall in the enrollment of native males.

For our purposes the interesting aspect of this claim is that Borjas seems to suggest that domestic and foreign graduate students are highly substitutable and display similar characteristics. In fact, other

[51] Skilled immigrants are defined to include both those coming under H1-B1 visas and employment-based immigration. Data sources include Freeman et al (2004); *Statistical Abstract of the United States* (various years); Institute for International Education, *Open Doors*, various years; and Department of Homeland Security, *U.S. Immigration Statistics*.

[52] In 1982 and again in 1984 legislation sponsored by Senator Simpson and Representative Mazzoli forbidding the employment in the United States of international graduates of U.S. universities passed both chambers of Congress before dying in the Conference Committee. In 1995 Senator Simpson and Representative Lamar Smith unsuccessfully resurrected the proposal.

[53] Senator Feinstein tried to put a moratorium on all international students soon after the September 11, 2001 attack. The proposal was shelved after protests from U.S. universities. Representative Rohrbacher has proposed that U.S. universities replace international students with domestic students although the latter may be less qualified.

information indicates that this assertion is questionable. Although data on the quality of domestic graduate student applicants compared to their international counterparts are not readily available, results from TIMMS and other international tests indicate that the native U.S. student pool for engineering and science programs is likely to be limited due to lower math and science achievement.[54] This suggests that student populations are not readily substitutable and that university technical training programs may have increased their demand for foreign students.

As a result it is not surprising that a recent study indicates that there has been a sharp drop in the proportion of PhDs in science and engineering awarded to U.S.-born males between the early 1970s and 2000 (Freeman et al., 2004). In 1966 these students accounted for 71 percent of science and engineering PhD graduates, while six percent were awarded to U.S.-born females and only 23 percent of doctoral recipients were foreign-born. The situation was reversed by 2000, when only 36 percent of doctoral recipients were U.S.-born males, 25 percent were U.S.-born females and 39 percent were foreign-born. Contradicting Borjas (2004), the authors found that foreign students were not substituted for domestic students.

The number of PhDs granted to undergraduates from U.S. institutions, most of whom were U.S. citizens, did not change much during this period, while there was substantial growth in the number of foreign bachelor's graduates obtaining U.S. doctorates. Thus the change in proportion is mostly due to the expansion of PhD programs, with a majority of the new slots being taken by foreign students rather than through substitution.

These same trends explain the fact that the proportion of foreign-born faculty with U.S. doctoral degrees at U.S. universities has gone up sharply during the past three decades, from 11.7 percent in 1973 to 20.4 percent in 1999. For engineering it rose from 18.6 percent to 34.7 percent in the same period.[55]

In the last few years, however, there has been a steep decline in foreign student applications for admission into U.S. universities and a corresponding increase in applicants to universities in Asia, Australia and New Zealand.[56] This is due both to difficulties in obtaining U.S. visas since 9/11 and to the fact that some countries are catching up to the United States with regard to attracting foreign students and skilled labor from abroad (Hira, 2003). Recent evidence also suggests that collaboration between foreign and US universities has shown marked increase during the past two decades and increasingly research activities are being "dispersed" abroad, particularly to Asian countries, partly to take advantage of complementary capabilities (Adams et al., 2004). Modern communication technologies and cuts in public funding presumably have contributed to this trend, and it is likely that if qualified students become increasingly unavailable in the United States the tendency will accelerate.

2c. University Research and Patenting

In the United States, patenting of new inventions by universities began to accelerate during the 1960s, although such institutions as Stanford had been innovating and attempting to patent inventions from the early 1920s (Etzkowitz, 2003; Henderson and Jaffe, 1998). University innovation and patenting were significantly boosted by the Bayh-Dole Act of 1980, which allowed U.S. universities to commercialize research results (Sampat et al., 2003; Mowery et al., 2001). Currently the determinants of university patenting in the United States and its implications for the economy are a central subject for inquiry (Lee, 1996; Thursby and Kemp, 2002; Jensen and Thursby, 2001; Thursby and Thursby, 2000; Owen-Smith and Powell, 2003).

[54] http://nces.ed.gov/pubs99/1999081.pdf
[55] http://www.nsf.gov/sbe/srs/seind02/append/c5/at05-24.xls
[56] http://smh.com.au/articles/2004/07/14/1089694426317.html?from=moreStories&oneclick=true

National governments typically play a significant role in financing research that supports patenting. Furthermore, there is also considerable university-industry collaboration, especially in the United States, with a significant proportion of research funding coming from industries (Cohen et al., 1994; Dasgupta and David, 2002; Agrawal and Cockburn, 2003; Link and Scott, 2003; Laursen and Salter, 2004). Indeed, U.S. state and federal budget cuts have created a vacuum in research financing that is increasingly being filled by both domestic and international corporations (Beath et al., 2003). For example, recently BMW set up a fund to finance most of the research of the Automotive Engineering Department at Clemson University in South Carolina.[57]

As noted earlier, prior studies of university patenting have not analyzed the role of skilled immigrants or foreign graduate students as inputs into the innovation production function. That role could be important as most countries in the world are not in a position to produce domestically all the skilled labor necessary for rapid technological development and innovation. Hence, they must rely on skilled immigration and foreign talent to augment their skills. Recent experience indicates that countries such as the United States, Australia, Singapore, and more recently, People's Republic of China, which have been relatively open to foreign talent, have experienced faster rates of economic growth than such countries as Germany, Japan and Korea, where opposition to any form of foreign talent is significant. Thus, it seems plausible from this experience that a relatively open-door skilled immigration policy could play an important role in innovation and follow-on growth.

## 3. Modeling Framework and Data

To estimate the contribution of skilled immigrants and foreign graduate students to U.S. innovation, we modify the "national ideas production function" that is widely used in innovation studies (Stern, et al, 2000; Porter and Stern, 2000). In this approach, the rate of new ideas produced depends on both the allocation of resources to the R&D sector, the productivity of those resources, the stock of ideas already in existence and the ability of that stock to support new invention. Note that this approach can determine whether prior research increases current R&D productivity (the "standing on shoulders" effect) or whether prior research has discovered the easier ideas and new invention becomes more difficult (the "fishing out" effect).

Our measures of new ideas production are total patent applications, total patents awarded, and patents granted to U.S.-based universities and other institutions and firms. All of these data refer to activities within the United States. Patents are not an ideal measurement of innovative output, primarily because patents vary widely in their economic and technical significance (Griliches, 1984). However, patenting activity is the most commonly used proxy in innovation studies and does capture three important aspects of innovation (Kortum, 1997; Stern, et al, 2000). First, patents do reflect an important portion of innovative output and are likely correlated with others, such as trade secrets and copyrights. Second, to be awarded a patent, inventions must be novel and non-obvious, suggesting that patent grants capture something new. Third, it is costly to apply for a patent, so the patenting entity believes there is something economically valuable about its technological innovation.

The primary novelty of our approach is in the definition of inputs into innovation. In prior studies these resources have been measured by R&D expenditures (perhaps broken into university and non-university sources) and scientists and engineers. We retain the use of these basic variables but incorporate international students and skilled immigrants as components of the inputs into idea generation. That is, we include the flow (enrollments) of international graduate students relative to total graduate students, the scaled number of skilled immigrants in the country, the scaled number of total PhD engineers and

[57] http://www.clemson.edu/centers/brooks/news/BMW.pdf

scientists, and scaled real expenditures on R&D. There is some overlap between skilled immigrants and engineers and scientists, but it is not possible with available data to distinguish sharply between these factors.

To capture the stock of existing knowledge we employ the accumulated number of patents awarded. Finally, we wish to estimate the aggregate ability of the economy to convert inputs and knowledge stock into new ideas. For this purpose we take this ability to be a function of time (capturing changes in U.S. ideas productivity) and key policy changes. The primary policy we consider is passage of the Bayh-Dole Act in 1980, which should have changed the ability of both universities and enterprises to convert technical inputs into new ideas.

To implement this structure econometrically, we account for several other factors. First, there is a lag between the time research inputs are utilized and the granting of a patent. It takes around five years on average, to conduct research in an area and apply for patents and another two years for patents to be awarded (Popp et al., 2003). The exact times for applications and awards vary according to the field. For pharmaceuticals it could take as long as fifteen years for patent applications, due to the lengthy period for clinical trials, and a further two years for the patent award (DiMasi et al., 2003). In contrast, in some areas of engineering it could take as little as three years for patent application and one year for patent awards. Thus, in the primary specification we entertain a five-year lag for patent application and a seven-year lag for patents awarded. We also test for the robustness of this assumption by using other lags.

Second, because we undertake time-series estimation, there may be problems with stationarity in the levels of patents, immigrants, and graduate students. Over the relevant period the absolute numbers of foreign students have increased steadily, as have patent applications. Thus, we scale relevant variables so that they are measured in proportion to the aggregate labor force, except that the number of foreign students is measured in proportion to total graduate students in the country.

Finally, we estimate equations capturing the determinants of total patents, university patents, and patents issued to other entities. Because the error terms associated with these equations are likely to be correlated our estimation technique is seemingly unrelated regression. Putting these ideas together yields two specifications. Our basic econometric specification is as follows.

$$IPA_{t+5} = \alpha_1 + \lambda_{F1}FORTGR_t + \lambda_{I1}IMCUM_t + \lambda_{S1}SK_t + \lambda_{R1}RD_t +$$

$$\phi_{1t}TOTPATSTOCK_t + \delta_{B1}BD + \theta_{1t}TIME_t + \eta_{1t}$$

$$IPG_{t+7} = \alpha_2 + \lambda_{F2}FORTGR_t + \lambda_{I2}IMCUM_t + \lambda_{S2}SK_t + \lambda_{R2}RD_t +$$

$$\phi_{2t}TOTPATSTOCK_t + \delta_{B2}BD + \theta_{2t}TIME_t + \eta_{2t}$$

In the first equation the dependent variable is total patent applications as a percentage of the U.S. labor force, five years after inputs are employed. These inputs include foreign graduate students as a percentage of total graduate students (FORTGR), skilled immigrants as a proportion of labor force (IMCUM), PhD's employed in science and engineering as a percentage of labor force (SK), and real research and development expenditures as a percentage of labor force (RD). We employ foreign students as a share of total students to permit identification of the impact of international graduate students, holding constant the total relative presence of graduate students in U.S. universities.

Regarding skilled immigrants we wish to have a measure that is comparable to such other variables as graduate students and engineers and scientists, which are defined as the total amount in activity (e.g., added over all

enrollments for students rather than new enrollments). Therefore, we define the variable IMCUM, which is the number of skilled immigrants cumulated over the preceding six-year period, divided by the labor force.

The estimation also includes the knowledge stock, as proxied by cumulative total patent stock over the past five years (TOTPATSTOCK), again divided by the labor force. Finally, there is a dummy variable capturing the Bayh-Dole Act, which takes on the value zero before 1980 and unity from 1980 onwards. The second equation is for patent grants and has the same structure, except that the independent variables enter with a seven-year lag.

Note that this first specification does not distinguish between university and non-university patenting activity because data from the U.S. Patent and Trademark Office did not make this distinction for patent applications in early years of the sample. However, patent grants are broken out in this way. Thus, a second series of equations distinguishes between patents awarded to universities and patents awarded to other organizations:

$$IPA_{t+5} = \alpha_1 + \lambda_{F1}FORTGR_t + \lambda_{I1}IMCUM_t + \lambda_{S1}SK_t + \lambda_{R1}RD_t +$$

$$\phi_1 TOTPATSTOCK_t + \delta_{B1}BD + \theta_{1t}\, TIME_t + \eta_{1t}$$

$$UIPG_{t+7} = \alpha_2 + \lambda_{F2}FORTGR_t + \lambda_{I2}IMCUM_t + \lambda_{S2}SK_t + \lambda_{R2}URD_t +$$

$$\phi_{U2}\, UPATSTOCK_t + \phi_{O2}\, OPATSTOCK_t + \delta_{B2}BD + \theta_{2t}\, TIME_t + \eta_{2t}$$

$$OIPG_{t+7} = \alpha_3 + \lambda_{F3}FORTGR_t + \lambda_{I3}IMCUM_t + \lambda_{S3}SK_t + \lambda_{R3}ORD_t +$$

$$\phi_{U3}\, UPATSTOCK_t + \phi_{O3}\, OPATSTOCK_t + + \delta_{B3}BD + \theta_{3t}\, TIME_t + \eta_{3t}$$

The first equation is the same as the initial equation in the pair listed above. The second equation captures patents granted to universities (UIPG) after a seven-year lag. It employs the same variables except it incorporates university real R&D expenditures, cumulative university and non-university patent stocks during the past seven years (UPATSTOCK and OPATSTOCK), all divided by labor force, and the dummy variable for the Bayh-Dole act. The third equation captures non-university patents awarded (OIPG) after a seven-year lag. It incorporates non-university real R&D (ORD) expenditures, cumulative university and non-university patent stocks (UPATSTOCK and OPATSTOCK), and the Bayh-Dole dummy.

In addition to these basic specifications, we incorporate into supplementary equations a variable SEDOCCUM, which is the number of doctorates awarded by U.S. universities in all areas of science and engineering, excluding social sciences, cumulated over the prior five years, again scaled by the labor force. The notion here is that, controlling both for total graduate students and the share of foreign graduate students, the number of successful finishers in science and engineering could provide further impetus to inventive activity in the United States.
By cumulating these graduates over the prior five years we actually capture the presence of ultimately successful students in the cohorts entering graduate school from ten to five years before patent registration.

A final observation is that graduate enrollments, and the split of graduate students between domestic and foreign students, may be sensitive to the state of the business cycle (Sakellaris and Spilimbergo, 2000). Failure to control for this possibility could risk finding spurious results and, accordingly, we incorporate into all equations the U.S. unemployment rate lagged in the same way as other independent variables.

These econometric models are implemented with annual data over the period 1965 to 2001.[58] The data were collected from a variety of sources. Figures on U.S. graduate students were gathered from the U.S. Department of Education *Statistical Quarterly*. No separate data were available on the number of U.S. graduate student enrollment in science and engineering for the entire period of analysis. Data on international graduate students were gathered from *Open Doors*, the publication of Institute for International Education. No data were available on international graduate students in science and engineering for the period prior to 1983 and hence total international graduate students had to be used as a proxy. This is not overly restrictive for approximately 80 percent of international graduate students enter science and engineering fields and most of the rest go into business fields and economics.[59]

Data on patents awarded to different institutions, such as universities and industry, were gathered from the National Science Foundation, *Science and Engineering Statistics* and from the website of the U.S. Patent and Trademark Office. Figures on research and development expenditures (divided by the GDP deflator), total number of scientists and engineers, recipients of doctoral degrees in science and engineering, total labor force, total number of international students and total skilled immigrants entering the country are available from the *Statistical Abstract of the United States* published annually by the U.S. Census Bureau. The GDP deflator and unemployment rate were taken from *Economic Report of the President*. Skilled immigrants are defined to include both those coming under H1-B1 visas (both capped and uncapped) and employment-based immigration. It should be noted that in our data these categories do not include accompanying family members, but just the workers themselves.

4. Empirical Results

Regression results for total patent applications and grants as a proportion of labor force are presented in summary form in Table 1 for our basic specifications.[60] These coefficients are taken from our preferred specification, which involves SUR estimation on all three equations in the second block above. It may be seen that lagged patent stock as a proportion of labor force had a significant and positive impact on patent applications in the first column.
The elasticity of patent applications with respect to increases in cumulative knowledge is estimated at around 0.53. This result suggests that, other things equal, there is a dynamic spillover from knowledge to the registration of new ideas, confirming the "standing on shoulders" idea.

Turning to the breakdown of grants, lagged patent stocks were significantly positive only in the university equations, with an elasticity estimate of 0.44. This suggests that inherited knowledge has a more powerful influence on innovation by universities than by other organizations. It is also noteworthy that the lagged university patent stock was estimated to have a small (but statistically insignificant) positive spillover impact on non-university patent grants. In contrast, lagged R&D expenditures had strongly positive effects on patent grants by other institutions, but not on total applications or awards to universities. This result is due partly to collinearity in the technical inputs data. Note that implementation of the Bayh-Dole Act appears to have induced significantly more patent applications and grants to both university researchers and to those in other institutions.

Both of our measures of technical personnel in the U.S. labor force, SEDOCCUM and SK, are estimated to have significantly positive effects on innovation as measured through patent applications in the

[58] Note in particular that we do not include the period after September 11, 2001. Our intent is to discover whether foreign students and skilled immigration could account for increases in technical productivity prior to that period, which may inform policy discussions in the ensuing era.
[59] See various issues of *Open Doors*.
[60] The results reported involve five-year lags for patent applications and seven-year lags for patent awards. We experimented also with different lag structures, which tended to reduce the significance of some coefficients but did not change the results materially.

first column. For example, SK (scientists and engineers in the labor force) had a powerful and positive impact, with an elasticity of 0.76. It had a stronger estimated impact on non-university patent grants. The estimated elasticity of university and non-university grants with respect to SEDOCCUM is over twice that of the elasticity of applications, itself computed to be 0.20.

Turning to the issues of central concern here, the presence of skilled immigration, cumulated over six years (IMCUM), is estimated to increase patent applications with an elasticity of 0.07 and to have a slightly larger impact on patent grants. Further, increases in foreign graduate students as a proportion of total graduate students (FORTGR) had a significantly positive impact on both applications and awards, with elasticities ranging between 0.48 and 0.68. It is interesting that the sensitivity of patent activity with respect to foreign graduate students is more than four times larger than that with respect to skilled immigration. This result strongly supports the view that the presence of foreign students in the United States is pro-innovation in relation to overall graduate enrollment.

Implementation of the Bayh-Dole Act had positive and significant impacts on later patent applications and grants all three equations. There was no suggestion of a significant residual time trend in applications, though the coefficients were negative in the non-university grants equations. Finally, the unemployment rate had no detectable effects on lagged patent applications or grants.

We put these elasticities in perspective by computing the implied impacts on patent levels from a change in enrollments or skilled immigration. Computed at sample means, a ten-percent rise in the ratio of foreign graduate students to total graduate students (FORTGR), holding total graduate students constant, would imply an increase in foreign students of 10,589.

Applying the estimated elasticity of 0.48 to the mean of the ratio of patent applications to labor force (IPA), holding constant the labor force, there would be an increase in later applications of 6,636 (or around 4.7 percent of mean total applications of 141,092). Thus, we compute a marginal impact of another foreign graduate student to be around 0.63 patent applications.

Turning to the breakdown into university and non-university awards, our estimates suggest that a ten-percent rise in the ratio of foreign graduate students would generate another 56 university grants (an increase of 5.3 percent of mean total grants of 1,068) and another 5,979 private (non-university) patent grants (an increase of 6.7 percent). It is evident that the enrollment of foreign graduate students ultimately generates more non-university patent awards, the number of which is far larger than university grants in any case, which may happen through a variety of channels. These estimated impacts on patent applications and awards are large figures in the context of U.S. patent flows.[61]

We can compute similar impacts from skilled immigration, using the corresponding coefficients on IMCUM. Thus, a ten-percent rise in the six-year cumulated number of skilled immigrants would increase later patent applications by 1,037 (0.7 percent of sample mean), university grants by 12 (1.1 percent) and other-institution grants by 814 (0.9 percent). It seems from these computations that skilled immigration has considerably smaller impacts on patenting activity than does enrollment of foreign graduate students. Finally, a ten-percent rise in the number of scientists and engineers in the labor force (SK), holding fixed the labor force, would increase later patent applications by 10,534 (7.5 percent of sample mean), university grants by 68 (6.4 percent) and other-institution grants by 5,660 (6.4 percent).

To summarize, larger enrollments of international graduate students as a proportion of total graduate students result in a significant increase in patents awarded to both university and non-university

[61] These figures are calculated at means across the entire sample. If these elasticities were applied to the far-higher average patent numbers in the late 1990s the corresponding predicted increases in innovative activity would be larger.

institutions as well as increases in total patent applications. This finding points out the importance of scientific contributions made by international graduate students in both settings. There are two likely reasons for this result beyond the direct impact of foreign graduate students on university innovation. First, research by foreign graduate students is likely to affect patenting by non-university institutions due to increasing collaboration between the academic and non-academic groups. Research is frequently sub-contracted by industries to universities with a share of royalties awarded to the contributing academic department. Furthermore, industries also tend to purchase the intellectual property rights of any discovery from the innovating university and hence tend to benefit indirectly from international student contributions.[62]

It is interesting that the results consistently show that foreign students, skilled immigrants, and doctorates in science and engineering play a major role in driving scientific innovation in the United States. It should be noted that our variable includes all graduate students and not just those in science and engineering. There are only a few observations available that distinguish between domestic and foreign graduate students in these technical fields. These data indicate that enrollments of domestic students as a proportion of total graduate students have remained fairly steady at around 65 percent in recent years. However, the former accounted for an average of only 45 percent of all graduating students during the 1990s, suggesting a significantly larger school-leaving rate. Furthermore, a significant proportion of U.S.-born students go into other fields, such as law and management, perhaps due in part to under-preparation in mathematics and science. Census data indicate that only nine percent of U.S.-born graduates work in scientific fields whereas 17 percent of foreign-born graduates work in scientific fields.

The results also indicate indirectly that the United States gains from trade in graduate education services. Relatively open access to international students has allowed U.S. universities to accept the brightest graduate students in science and engineering from all over the world. In turn, international graduate students contribute to innovation and patenting. Presumably, this is because international graduate students are relatively concentrated in such fields as science and engineering. Indeed, in a number of highly ranked engineering schools, international students account for nearly 80 percent of doctoral students, while in fields such as law they rank as low as one percent.[63]

Further, because of work restrictions for international students, domestic students have greater opportunities to be employed in non-research activities in both university and non-university institutions. Hence, it is not surprising that the presence of international students along with skilled immigrants, including international faculty, exchange visitors, research fellows and post-doctoral research associates, is a significant factor behind sharp increases in innovation and patenting at universities.

## 5. Concluding Remarks

This study provides the first systematic econometric results about the contributions of foreign graduate students and skilled immigrants to U.S. innovation and technological change. While it may have become conventional wisdom in some circles that these personnel flows contributed extensively to learning in the United States, the idea had not been tested. Our results strongly favor the view that foreign graduate students and immigrants under technical visas are significant inputs into developing new technologies in the American economy. The impacts are particularly pronounced within the universities but spill over as well to non-university patenting.

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[62] Dasgupta and David (1992) and Cohen, Florida, and Goe (1994), Laursen and Salter (2004)

[63] *Open Doors*, Institute for International Education

The significant contributions of international graduate students and skilled immigrants to patenting and innovations in the United States may have international and domestic policy implications. At the international level, it is evident that the United States has a significant direct comparative advantage in exporting the services of higher education, especially in training scientists, engineers, and related personnel. This situation is broadened by the contributions of foreign students to innovation in the United States, whereby the indirect impact of technical education is additional patent rents.

However, as other countries such as Singapore improve their offerings of scientific graduate education and encourage them to stay on after graduation, visa restrictions in the United States could have adverse implications for competitiveness. Specifically, global liberalization of higher education services would permit U.S. universities to get around visa problems by locating research campuses in other countries that welcome international talent (Amsden and Tschang, 2003). It is also noteworthy that U.S. corporations have significantly increased patenting activity and innovation abroad (Maskus 2000) and recent evidence indicates that the U.S. universities are also increasingly collaborating with universities abroad (Adams et al. 2004).

One of the striking implications of the current paper is that reducing foreign students by tighter enforcement of visa restraints could reduce innovative activity significantly. Indeed, with the rapid economic development of countries in regions such as South East Asia and with global job mobility increasing, such restrictions are likely to be self-defeating, at least in economic terms.

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**Table 1. International Students, Skilled Immigration, and Patenting Activity in the United States, 1965-2001**

| | IPA | UIPG | OIPG |
|---|---|---|---|
| CONSTANT | 5.068<br>(3.09)* | 2.705<br>(1.29) | 3.589<br>(2.31)** |
| FORTGR | 0.480<br>(7.46)* | 0.604<br>(3.64)* | 0.676<br>(5.95)* |
| SEDDOCCUM | 0.200<br>(2.03)** | 0.445<br>(2.82)* | 0.564<br>(5.09)* |
| IMCUM | 0.075<br>(2.40)** | 0.128<br>(2.78)* | 0.092<br>(2.63)* |
| SK | 0.762<br>(3.00)* | 0.732<br>(1.71)*** | 0.940<br>(3.25)* |
| RD | -0.177<br>(-1.19) | | |
| URD | | 0.021<br>(0.10) | |
| ORD | | | 0.383<br>(2.46)** |
| TOTPATSTOCK | 0.526<br>(3.96)* | | |
| UPATSTOCK | | 0.439<br>(1.83)*** | 0.183<br>(1.10) |
| OPATSTOCK | | 0.211<br>(0.56) | -0.158<br>(-0.51) |
| BD | 0.140<br>(2.55)** | 0.288<br>(3.13)* | 0.257<br>(4.22)* |
| TIME | -0.007<br>(-1.29) | 0.014<br>(0.57) | -0.040<br>(-3.67)* |
| UNEMPLOY | 0.006<br>(0.13) | 0.141<br>(1.60) | 0.037<br>(0.72) |
| R-Squared | 0.94 | 0.99 | 0.94 |
| DW | 1.60 | 1.82 | 2.52 |

Notes: IPA is patent applications and IPG is patents granted, both as a percentage of labor force. FORTGR is foreign graduate students as a proportion of total graduate students. TOTGR is total graduate students as a proportion of labor force. SEDDOCCUM is the cumulative number of doctorates earned in engineering and science in U.S. universities over a period of five years as a percentage of labor force. IMCUM is the cumulative number of skilled immigrants over a period of six years as a proportion of the labor force. SK is total PhD scientists and engineers as a proportion of labor force. RD is total real R&D expenditures as a proportion of labor force. TOTPATSTOCK is cumulative patents awarded as a proportion of labor force. BD is the dummy variable for the Bayh-Dole Act. Variables in the IPA equations are lagged five years, while those in the IPG equations are lagged seven years. Figures in parentheses are t-ratios and marked as significantly different from zero at the one-percent (*), five-percent (**) and ten-percent (***) levels.

# International Students

# and

# U.S. Policy Choices

**By Stuart Anderson, Executive Director**

**National Foundation for American Policy**

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## Executive Summary

The United States has lost its edge in attracting and enrolling international students in U.S. universities. This is particularly troubling in science and engineering at the graduate school level and carries implications for America's economy, its technological leadership and its role in the world. Obstacles remain that prevent the United States from significantly increasing the enrollment of international students at U.S. universities. Policy improvements can be made in several areas that will help ensure American leadership in international education and a strong scientific and technological foundation for the nation. The research in this paper was commissioned by the Merage Foundations for the "Leadership Forum on Foreign Student Admission and Enrollment in U.S. Graduate Schools," held October 16 and 17, 2005, and cosponsored by the Merage Foundations and the University of California-Irvine.

Although the trend line is relatively short and, therefore, could change, data on international students indicate genuine problems have emerged.

- Enrollment by international graduate students in U.S. engineering programs declined by 8 percent between 2003 and 2004, according to the Council of Graduate Schools, while life sciences experienced a 10 percent decline in international graduate student enrollments between 2003 and 2004.

- The enrollment of international students overall declined by 2.4 percent between the 2002/2003 and the 2003/2004 academic years, according to the Institute of International Education.

- Between FY 2001 and FY 2004, the number of F-1 visas issued for international students declined by 25 percent, according to the U.S. Department of State.

Reviewing the literature and interviewing individuals involved in international education provides a clear picture of the current obstacles against increasing international student enrollment:

- U.S. Visa Policy**:** Tighter screening is only one visa-related issue and not necessarily the primary cause of most international student visa denials by U.S. consular officers. The requirement that international students and other temporary visa applicants prove they do not intend to stay permanently in the United States, known as 214(b), is the primary reason consular officers cite for denying visas for international students. At a time when a nation's success is based not only on its laws and institutions but also the skills of its workforce, U.S. policy specifically blocks the entry of bright foreign nationals who plan to study and later work in the United States.

- Competition: Just like America is no longer the only place to buy a world-class airplane or automobile, options for individuals seeking a world-class education have increased. U.S. universities' market share of international students fell from 36.7 percent in 1970 to 30.2 percent in 1995. In other words, this trend started before September 11, 2001, but recent policies have made it more difficult to reverse. Efforts in the United Kingdom, Australia, Germany, France, and Japan have increased enrollments in those nations, while the option of staying home to attend university has become more attractive as educational and employment opportunities have improved in China, India, and elsewhere.

• **Cost: The cost of a U.S. graduate school education can be prohibitive for people from many countries.**

• Ability to Work in the United States: One reason individuals have sought to study in America is the opportunity it presents to work in the United States after completing his or her studies. The less realistic that opportunity becomes, the less likely for students to choose a U.S. university over a school in another nation, including one in their own country.

The United States, like any nation, has the capacity to change policies when it is in its interest to do so. Today, it is in America's interest to change policies to increase the enrollment of international students and facilitate their success in America. The "prescription for change" to achieve these objectives includes:

• First, eliminate the requirement that to obtain a visa individuals pursuing master's and Ph.D.s in the United States must demonstrate they will return to their home country. Amending 214(b) of the Immigration and Nationality Act to exclude international graduate students from the requirement they must intend to leave after completing their studies would be a logical extension of the law Congress passed last year to exempt up to 20,000 foreign nationals a year who graduate with a master's degree or higher from a U.S. university from being counted against the annual limit on H-1B visas for skilled professionals.

• Second, the United States should streamline the immigration process for international graduate students in science and engineering. International students earned nearly 60 percent of U.S. doctorates awarded in engineering in 2002. It is in America's interest that as many of those individuals as feasible stay and work in the private sector, perform research in our labs, or teach at U.S. universities. There are various policy options that can be pursued to make it easier for international students with advanced degrees to transition to lawful permanent residence. Congress could allow employers to sponsor such students without having to file for "labor certification," an often bureaucracy-driven process by which employers must demonstrate a shortage exists for that type of worker.
Another approach would be to create a new visa category for international graduate students who have completed their U.S. studies, which would allow such individuals to avoid the current backlogs that plague the employment-based immigrant categories.

• Third, to deal with both policy and processing problems, the U.S. government needs to increase accountability and improve coordination among the numerous departments with authority over international students. One approach would be to require a single Administration official to coordinate policy and act as an "Ombudsman" on international student issues. This would lead to a logical setting of priorities to balance security and other interests.

• Fourth, U.S. universities need to increase their marketing abroad to attract international students to the United States.

- Fifth, universities, businesses, and the U.S. government need to work together on a strategic plan to convey the message that America is the best place to gain an education. The time has passed when America "sold itself" as the destination of choice for international students.

- Finally, to the extent the United States will continue to provide financial assistance to other nations, we should consider providing part of that assistance in the form of need-based vouchers to qualified international students from those nations to study at U.S. universities. This would turn a portion of foreign aid into student aid spent in the United States for tuition and room and board, while providing an opportunity to educate and expose individuals to America who do not possess the resources to self-fund a U.S. college education. Assistance of any kind is most effective when it is tangible and directly affects the lives of individuals. While the U.S. government funds the Fulbright Program for approximately 1,300 international students a year, the proposal here is for a broader approach that becomes part of our foreign aid packages aimed at the developing world.

The door has not shut closed on international students. We still possess a window of opportunity to improve our policies and enhance America's standing as the place where one can come to study and learn. It is in our national interest that we seize this opportunity.

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The United States has lost its edge in attracting and enrolling international students in U.S. universities. This is particularly troubling in science and engineering at the graduate school level and carries implications for America's economy, its technological leadership and its role in the world.

Reviewing the literature and interviewing individuals involved in international education provides a clear picture of the obstacles against increasing international student enrollment at U.S. universities. However, there are also solutions available that would allow America to regain its edge in the enrollment of international students and help ensure the country maintains a strong scientific and technological foundation.

Although the trend line is relatively short and, therefore, could change, data on international students indicate genuine problems have emerged. Between FY 2001 and FY 2004, the number of F-1 visas issued for international students declined by 25 percent, according to the U.S. Department of State.[i] The number of student visas issued does not correspond directly with the enrollment of international students, since even students who receive visas may ultimately choose not to attend a school. But unless a student receives a visa to enter the United States he or she cannot enroll at a U.S. university.

Enrollments are a key indicator to watch, since ultimately how many international students enroll in universities is the most direct way of measuring whether or not international students are attending U.S. universities in increasing numbers. Enrollment by international graduate students in U.S. engineering programs declined by 8 percent between 2003 and 2004, according to the Council of Graduate Schools. Life sciences experienced a 10 percent decline in international graduate student enrollments between 2003 and 2004.[ii] (The enrollment of international students overall declined by 2.4 percent between the 2002/2003 and the 2003/2004 academic years, according to the Institute of International Education.)[iii] The Council of Graduate Schools also reports that international graduate student applications declined in each of the past two years.[iv]

One can point out a troubling trend without claiming the sky has collapsed. U.S. universities' market share of international students fell from 36.7 percent in 1970 to 30.2 percent in 1995.[v] In other words, this trend started before September 11, 2001, but the evidence is that recent policies have made it more difficult to reverse. The countervailing view is that total enrollment of international students in the United States is higher today than prior to September 11, 2001.[vi] Yet that ignores a significant interruption in the annual increases in enrollments that had occurred over the prior years. Simply put, a consensus has emerged that America is confronting genuine problems in attracting international students to enroll at U.S. universities, particularly in graduate level science and engineering.

The numbers tell only part of the story and international students are not the only issue. "We've seen foreign scientists try to get here to do research and can't get in who not only go elsewhere but are so upset they say they will not come to the U.S. now under any circumstances," said Robert Gelfond, CEO of MagiQ Technologies in New York, selected by *Scientific American* as one of the country's most innovative companies.

"Clearly we are losing our ability to attract talented people, since the word has spread about the difficulties of getting into the United States. Individuals have to plan their lives and can't afford to spend months and months putting everything on hold only to discover they won't be able to come to America after all."[vii]

The National Academy of Sciences and sister organizations sounded similar concerns in a May 2005 report *Policy Implications of International Graduate Students and Postdoctoral Scholars in The United States.* The report concluded, "International students contribute to U.S. society not only academically and economically, but also by fostering the global and cultural knowledge and understanding necessary for effective U.S. leadership, competitiveness, and security."[viii] It warned: "If the United States is

to maintain overall leadership in science and engineering, visa and immigration policies should provide clear procedures that do not unnecessarily hinder the flow of international graduate students and postdoctoral scholars."[ix]

A recent paper by economists Richard Freeman, Emily Jin, and Chia-Yu Shen for the National Bureau of Economic Research demonstrated that since the 1960s America has significantly increased its reliance on the foreign-born as a source of Ph.D.s in science and engineering. "In 1966, 71 percent of science and engineering Ph.D. graduates were U.S.-born males . . . and 23 percent were foreign born. In 2000, 36 percent were U.S.-born males . . . and 39 percent were foreign-born." In addition, the paper noted a significant rise in the proportion of foreign-born scientists and engineers who obtained their undergraduate degree abroad before coming to the United States for a Ph.D.[x] It is noteworthy that the nation saw this large increase in the percentage of foreign-born who obtained U.S. Ph.D.s at the same time, as Freeman, Jin, and Shen point out, U.S. minorities and women showed significant increases in obtaining Ph.D.s in these fields.

Additional research by Richard Freeman shows that the European Union granted 40 percent more Ph.D.s in science and engineering than the United States in 2001 and that the E.U. is projected to produce twice as many science and engineering doctorates as America by 2010. Freeman points out there are concerns that as other nations outstrip the capacity of the United States to produce highly-skilled scientists and engineers more high-value work will flow out of this country and be performed elsewhere.[xi]

Today, more than 50 percent of the engineers with Ph.D.s working in the United States are foreign-born, according to the National Science Foundation. In addition, 45 percent of math and computer scientists with Ph.D.s, as well as life scientists and physicists, are foreign-born. Among master's degree recipients working today, 29.4 percent of engineers, 37 percent of math and computer scientists, and 25 percent of physicists are foreign-born.[xii] Many of these individuals first came to the United States as international students. There are other overlooked benefits of international students and immigrants. A National Foundation for American Policy study found that over 60 percent of the finalists in the 2004 Intel Science Talent Search – the top high school science students in America – were the children of immigrants. And 20 percent of those parents came to the United States as international students.[xiii]

Statistics do not tell the whole story. Dr. Jagdish Kumar Aggarwal, who received a master's and Ph.D. from the University at Urbana-Champaign, was awarded the 2005 IEEE Lean K. Kirchmayer Graduate Teaching Award from the Institute of Electrical and Electronics Engineer (IEEE), an organization that has often opposed the entry of skilled foreign-born professionals to America. Dr. Aggarwal, a professor of engineering at the University of Texas at Austin, served as director of NATO's Advanced Research Workshop on Multisensor Fusion for Computer Vision.[xiv] More than one-third of American university engineering faculty with Ph.D.s is foreign-born.[xv]

Other examples of outstanding international students include Sergey Brin, founder of Google, who came to the United States as a student at Stanford University, Andy Bechtolsheim, a German-born founder of Sun Microsystems, who came to America to study electrical engineering at Carnegie-Mellon University and later Stanford, and many others. The governments of nations around the world contain many high-ranking officials who attended U.S. universities.[xvi]

## Understanding the Obstacles to Increasing International Student Enrollment

The first to voice alarm about the impact of post-September 11, 2001 policies on the enrollment of international students was NAFSA: Association of International Educators. NAFSA's January 2003 task

force report *In America's Interest: Welcoming International Students*, concluded, "Rather than retreating from our support for international student exchange – and forgoing its contribution to our national strength and well being – we must redouble our efforts to provide foreign student access to U.S. higher education while maintaining security."[xvii]

The business community expressed concern publicly about the impact of visa and international student policies on the long-term competitiveness of U.S. firms. Microsoft Chairman Bill Gates has called the policy "a disaster." Meanwhile, Jeff Immelt, chairman and CEO of General Electric, said, "This is a case where our policy to close down on access boomerangs. It moves jobs out of the United States and creates less incentive for people to study the U.S." [xviii]

Specifically, the policies referred to tightened admission into the United States, lengthened processing times, and made it less likely for an international student to receive a U.S. visa than prior to the September 11, 2001 attacks. But one should not view this as a case of unintended consequences. A widespread public perception took hold after the attacks on New York and Washington, D.C. that it is too easy to enter the United States from abroad. Members of Congress, in particular, excoriated consular officers, while criticism of Mary Ryan, assistant secretary of state for consular affairs, forced her retirement from the State Department after she lost support from her superiors. Three of the September 11, 2001 hijackers had some connection to international study, though none were full-time international students enrolled in four-year or graduate degree programs. Two had changed their status from visitor to student to enroll in flight schools and another had enrolled in a language program.[xix]

In response to measures passed by Congress the State Department required nearly all visa applicants to be interviewed in person, significantly increasing the workload in consulates around the world. Additional or more intensive security clearances became required for individuals from certain countries and studying in certain fields. New regulations and tighter enforcement made it more difficult to enter on a visitor visa and change to student status inside the country. It also became more problematic to travel back and forth from one's home country to the United States for people who were not green card holders. Perhaps most importantly, visas that may have been approved in the past turned into denials, as signals from Washington, D.C. influenced the decisions of consular officers. Between 2001 and 2003 the number of visa applications refused for F-1 students increased from 27.3 percent to 35.2 percent.[xx]

To better understand the impediments to increasing international student enrollment at U.S. universities, particularly in science and engineering at the graduate level, let's look at the process and the issues facing a typical international student.

Susan Lin, although a composite of different individuals, reflects the experience of many international students.[xxi] Susan is completing an undergraduate degree in Beijing and would like to study abroad to obtain a Ph.D. in electrical engineering to conduct research in nanotechnology, a field many experts believe will produce numerous commercial applications in the coming years. Susan knows that America's engineering schools are reputed to be the best in the world but she has heard many stories about problems obtaining a visa.

One reason Susan might want to apply to an American university is to work at the cutting edge in her field. She is uncertain whether China will provide that type of opportunity. However, she also knows that it has become more difficult for high-skilled foreign nationals to obtain work visas in the United States.

Susan was advised by a friend that starting in 1997 and continuing to the present, foreign nationals have seen their ability to be hired by U.S. companies limited by the exhaustion of the annual H-1B visa quota for professionals, primarily in high technology fields. In FY 2005, the entire annual allotment of H-1B visas was used up on the first day of the fiscal year. That meant several months went by in FY 2005, as

it had in previous years, when a U.S. employer could not hire a foreign national on an H-1B visa. (In FY 2005, Congress permitted the annual allotment to fall back to 65,000 visas a year after having raised the total in prior years.) Similarly, Susan read in the newspaper that prior to the start of FY 2006 the Department of Homeland Security announced that it had received enough applications to exhaust the supply of H-1B visas before the fiscal year even began. She also knows that it can take years to obtain a green card (permanent residence) in the United States due to processing delays.[xxii]

Susan has heard from friends that countries besides the United States seem more interested these days in attracting students like her. The statistics bear out this perception. While U.S. enrollment of Chinese students has been mostly flat in recent years, the United Kingdom experienced a 25 percent increase between 2003 and 2004, according to the British Council director of examinations in China. Australian Universities have seen similar growth in Chinese student enrollment.[xxiii]

Susan is concerned, too, about costs. One reason she decided against attending a U.S. university as an undergraduate is it would have been too much of a financial strain on her family, since few scholarships are available for international students at that level. She understands there is more money available from U.S. universities for international students for graduate school. According to the Institute of International Education more than 40 percent of international graduate students list a U.S. university as their primary source of funds, compared to only 10 percent of (foreign) undergraduate students.[xxiv] Still, that means over 50 percent of foreign graduate students must rely primarily on personal or family funds. Moreover, even the 40 percent who receive a majority of their funding from a U.S. university must often supplement that with personal or other funding to afford schooling in the United States. Susan knows that international students are not eligible to receive U.S. government grants (Pell Grants) or participate in the federal student loan program; international students must pay out of state tuition at public universities. She has read that legislators in some U.S. states have argued that international students take educational opportunities away from their state's residents, although no laws have yet been enacted at the state level to restrict international students in a serious way.

After weeks of indecision, Susan applies and eventually is accepted to three American graduate schools and one British university. She decides to attend the University of Texas at Austin because she is impressed with the engineering program and she was offered a financial aid package that will make the school more affordable for her family. Moreover, two of the school's professors, Dr. Aggarwal and Dr. Jacob Abraham, are known to her professor in Beijing and she is eager to study under them. Like Dr. Aggarawal, Dr. Abraham also came to the United States as an international student and, with over 300 publications, is among the most cited researchers in the world.[xxv]

Unlike a U.S. student, when a foreign national is accepted to an American college that is only half the battle. To enter the United States to enroll at the University of Texas at Austin, Susan must apply for a visa at the U.S. embassy or at one of the American consulates in China. The State Department gives priority for international student interviews, so she receives her appointment time within a few days. Fortunately, she lives in Beijing and can easily access the embassy. But if she lived far away, she might have to fly and stay in a hotel in order to attend the interview.

Contrary to popular impression, the vast majority of denials for student and other visas have little to do with national security. This makes sense, since relatively few of the more than 5 million people annually who receive a temporary visa to the United States represent any threat of criminal or terrorist activity.

The primary cause of most international student visa denials by U.S. consular officers is the requirement that international students and other temporary visa applicants prove they do not intend to stay permanently in the United States. Section 214(b) of the Immigration and Nationality Act states that "every

alien… shall be presumed to be an immigrant until he establishes to the satisfaction of the consular officer, at the time of application for a visa… that he is entitled to nonimmigrant status…"

While this requirement has been on the books for decades, the evidence indicates it became more strictly enforced after September 11, 2001. A U.S. Embassy official in China has said that he tells "every Congressman and Senator I meet that 214(b) really is a problem for students and U.S. institutions."[xxvi] In other words, U.S. consular officers deny visas to individuals who they believe may stay in the United States after completing their education, even though it may be beneficial for America if such individuals, in fact, remained to work or teach here.

It is the reality of this policy that Susan Lin must face when she enters the U.S. embassy for her interview. When the interview starts, Susan tugs at her hair and grows nervous, knowing a wrong answer (or even her demeanor) could cost her an opportunity to study in the United States.[xxvii] In other words, this interview can change her life. The consular officer reviews the financial records, since an international student must demonstrate he or she is capable of funding the education through personal or other means. It appears that between her family's assets from the bank records and the financial package offered by the University of Texas at Austin there is enough money to fund Susan's studies.

"What do you plan to do after you receive your degree in electrical engineering?" asks the consular officer.

Susan knows working in the United States is an uncertain proposition. Moreover, she has learned that three years is a long time and it would appear boastful to tell anyone that after graduating she plans to get a job at a top American company. More importantly, she has heard that consular officers frown upon those who they believe plan to stay in the United States after completing their studies.

"I plan to come back to China after studying in America," says Susan.

"Don't you want a job in America?" he asks.

"I don't know if I would be good enough for that. My father is an engineer and I think he can help me get a job in Beijing once I come back with an American degree," says Susan.

After a few more questions, the consular officer thanks Susan. The interview lasted less than five minutes. If the officer believed Susan intended to stay in the United States, he would have denied her on the spot under 214(b) as an "intended" immigrant. Instead, he tells her she will receive notification in about a month. This is because since Susan is a Chinese national and planning to study at the graduate level in a technology field, her visa application will undergo an additional level of screening called Visas Mantis. The Visas Mantis process was developed administratively by the State Department and requires interagency clearance for "visa applications for persons to study or work in certain sensitive scientific and technical fields" to "screen against the illegal transfer of technology."[xxviii]

Visas Mantis is a good example of the ebb and flow of policymaking often missed by the public. When the impact of post September 11, 2001 policies became clear, the education community and the media reacted, particularly when confronted with incidents of year-long waits for approvals and discouraged or denied students.
As recently as October 2003, more than 40 percent of the Visas Mantis cases took more than 45 days to clear, due in part to the increased workload of other security advisory opinions. Today, fewer than 15 percent of Visas Mantis screenings take longer than 30 days.[xxix]

Weeks go by and Susan worries. She wonders if there is still time to tell the school in England she wants to go there instead. She is unsure what to do. Finally, four weeks after her interview, Susan receives word that her visa application has been approved. She is coming to America.

Susan overcame a number of hurdles to be able to enroll at a major U.S. university. Not everyone succeeds. The many obstacles in their paths can thwart even the most determined international students. For that reason these impediments will need to be addressed if the United States is to expand the enrollment of international students, particularly in science and engineering.

## A Prescription for Change

To increase international student enrollment and maintain a steady flow of talented individuals into fields important to America, while also balancing security concerns, it is necessary to change certain policies and promote new approaches to international education. These changes would involve government, business and universities.

First, change the requirement that to obtain a visa individuals pursuing master's and Ph.D.s in the United States must demonstrate they will return to their home country. In the past, Congress has changed the law to allow other types of visas, such as H-1B and L visas, to become what is called "dual-intent," meaning an individual should not be denied a visa because they may intend to stay (lawfully) in the United States after their temporary period of admission expires.

Amending 214(b) of the Immigration and Nationality Act to exclude international graduate students from the requirement they must intend to leave after completing their studies is a logical extension of the law Congress passed last year to expand the H-1B quota. Under the new law, up to 20,000 foreign nationals a year who graduate with a master's degree or higher from a U.S. university are exempt from being counted against the annual limit on H-1B visas.[xxx] This change in the law did not prove controversial and seemed a logical way for the United States to retain valuable human capital. It raises an obvious question: Why would U.S. policy provide an exemption so international graduate students can stay here and work, while retaining a law elsewhere in the code that prevents such students from entering the U.S. if consular officers divine such students actually intend to stay here and work?

Amending 214(b) as it applies to graduate students, an action recommended by the National Academy of Sciences panel, would increase the ability of U.S. universities to attract outstanding students.[xxxi] It would also be more politically saleable than attempting to eliminating it entirely for all international students.

Catheryn Cotten, director, international office, Duke University, relates the story of a Chinese student earning a Ph.D. in a scientific field who went home to visit and could not receive another visa because the consular officer accused her of wanting to stay in the United States to work after completing her Ph.D. This demonstrates the self-defeating nature of U.S. policy. American officials should *hope* a scientist receiving a Ph.D. from Duke University wants to stay in America. After a number of months the student from China was eventually allowed to reenter the United States but as Catheryn Cotten says, "Students are scared. They need to go home, they need to travel, but are now often afraid to do so."[xxxii] Students stranded out of the country for months can see their research efforts destroyed if they are part of projects that involve cooperation with other researchers.

Second, the United States should streamline the immigration process for international graduate students in science and engineering. International students earned nearly 60 percent of U.S. doctorates

awarded in engineering in 2002.[xxxiii] It is in America's interest that as many of those individuals as feasible stay and work in the private sector, perform research in our labs, or teach at U.S. universities.

> A key existing impediment under the current system is that a company must hire a highly-skilled foreign national on a temporary visa, normally an H-1B visa. But as noted earlier, the supply of H-1B visas has been sporadic, creating uncertainty. "We have heard from faculty who travel abroad that the prospect that people won't be able to work in the United States after completing their studies is a major concern," says Duke's Catheryn Cotten. An opportunity to work in America can be part of the attraction of studying here, often justifying the enormous financial investment international students must endure to attend a U.S. college. The uncertainty created by inadequate quotas and processing delays sends the signal to ambitious applicants that the United States may no longer be the place to fulfill your dreams. The annual quota on H-1B visas should be raised sufficiently to prevent the backlogs and delays caused each year under current law.[xxxiv]

After completing his or her degree, an international student must be sponsored by a U.S. employer to become a lawful permanent resident. The problem is that the process can take two years or longer, given the delays and backlogs at the Department of Labor and Citizenship and Immigration Services. The country quotas in place for employment-based green cards are resulting in even more significant backlogs for Indian and Chinese professionals sponsored for permanent residence by U.S. companies and universities. Tracy Coon, director of corporate affairs, the Intel Corporation, proposes that the United States grant lawful permanent residence to foreign-born graduate students in science and engineering as a matter of course.[xxxv]

There are various policy options that can be pursued to make it easier for international students with advanced degrees to transition to lawful permanent residence. Congress could allow employers to sponsor such students without having to file for "labor certification," an often bureaucracy-driven process by which employers must demonstrate a shortage exists for that type of worker. Another approach would be to create a new visa category for international graduate students who have completed their U.S. studies, which would allow such individuals to avoid the current backlogs that plague the employment-based immigrant categories.

Third, to deal with both policy and processing problems, the U.S. government needs to increase accountability and improve coordination among the numerous departments with authority over international students.[xxxvi]

One approach would be to require a single Administration official to coordinate policy and address emerging problems. That person could chair a coordinating council that would periodically meet on international student issues. This would lead to a logical setting of priorities to balance security and other interests, and would inject accountability into policies affecting international education. In the weeks following September 11, 2001, such an individual would have been able to take charge and ensure that proposed policy changes would achieve their stated objectives, fit into the nation's overarching goals on science, education, and foreign policy, and were properly resourced to avoid the types of significant processing delays witnessed in 2002 and 2003. Marlene Johnson, Executive Director and CEO of NAFSA: Association of International Educators, believes such an individual needs to be located in the White House, and that the message from that official should be connected to our overall message to the world about the United States. Whether or not this individual is placed in the White House, given the importance of the issue a designated center of authority and focus would greatly enhance the country's ability to address international issues and the role they play in the U.S economy and foreign policy.

Fourth, U.S. universities need to increase their marketing abroad to attract international students to the United States. While certainly there are U.S. schools that do market themselves abroad, the increased

competition means more will need to be done by any school hoping to enroll more international students. The lingering negative impressions related to U.S. visa policies and increased competition means that old methods may be insufficient to convince students abroad that a particular U.S. institution is their best option. “Schools should absolutely increase their marketing,” said NAFSA’s Marlene Johnson. “While we need a marketing plan as a nation for international education individual universities need to compete abroad to attract students.”[xxxvii]

“Government-supported efforts by competing host countries, including nationally coordinated campaigns by the U.K., Australia, Germany, France, Japan, and others with sophisticated marketing strategies and expedited visa policies, are proving very persuasive, especially to self-funded students from some of the largest sending countries such as China,” writes Peggy Blumenthal, vice president for educational services, Institute of International Education. “Several of these countries, along with others in Asia and Europe, have allocated tens of millions of dollars to launch sophisticated marketing strategies over the past few years.”[xxxviii]

Fifth, universities, businesses, and the U.S. government should work together on a strategic plan to convey the message that America is the best place to gain an education. The time has passed when America “sold itself” as the destination of choice for international students. Negative publicity about the difficulties of gaining a visa and avoiding U.S. processing hassles more generally have affected the perception of America as a desirable place to work and study for foreigners with other options.

The “Opening Doors for Foreign Students Act of 2005,” which was included as an amendment to legislation that passed the U.S. House of Representatives in July 2005, requires “the development of a comprehensive strategy by the Secretary of State, in consultation with the Secretaries of Homeland Security, Education, and Commerce, to attract foreign students to study in the United States.”[xxxix] This legislation followed prior bills, which did not become law, authored by Senator Norm Coleman (R-MN) that would, among other things, require a U.S. strategy for international education.[xl]

A House resolution, introduced in 2005 but not acted on, sponsored by Reps. Jim Kolbe (R-AZ) and James Obestar (D-MN) declares, “It is the sense of Congress that the United States should establish an international education policy to foster mutual understanding and respect among nations, promote a world free of terrorism, further United States foreign policy and national security, and enhance United States leadership in the world.” The resolution states: “New security measures have had the unintended effect of weakening the United States position as the leading destination of international students seeking higher education.” Among other things, it calls for establishing an international education policy to “ensure that visa and employment policies promote increased access to the United Sates by international students, scholars, and exchange visitors, consistent with homeland security.”[xli]

To the extent they are not doing so already, universities should work with businesses that maintain offices abroad to encourage at least minimal partnerships in promoting American colleges. While the primary responsibility of U.S. companies is to run their business in a profitable manner, companies will also see it in their interest to help American universities promote themselves both individually and collectively. The U.S. Department of Education and U.S. Department of State can formulate a broader campaign, in cooperation with universities, to advertise America as a place to gain an education. If they do not already, governors who often travel abroad to attract investment should be encouraged by universities in their states to promote state schools overseas. An effort launched in 2001 by the Indiana Department of Commerce and the Indiana Consortium of International Programs, made up of Indiana universities, is credited with increasing the state from 13$^{th}$ to 10$^{th}$ among the most popular American destinations for international students.[xlii]

To help deal with the expense of a U.S. university education, Duke University and some other universities are setting aside resources obtained from private sources to provide financial assistance for international students, in part under the belief that providing exposure on campuses to students from different nations also benefits U.S. students. Duke's Fuqua School of Business provides low-interest loans for international students in its graduate program. A task force of educators convened by NAFSA, the Committee on Institutional Cooperation, and Indiana University recommended that universities consider developing endowments aimed at support for international students attending their schools.[xliii] Marshall Kaplan, executive director of the Merage Foundations, recommends a business and foundation fund that can provide students with financial assistance.

Finally, to the extent the United States will continue to provide financial assistance to other nations, we should consider providing part of that assistance in the form of need-based vouchers to qualified international students from those nations to study at U.S. universities.
This would turn a portion of foreign aid into student aid spent in the United States for tuition and room and board, while providing an opportunity to educate and expose individuals to America who do not possess the resources to self-fund a U.S. college education.

Assistance of any kind is most effective when it is tangible and directly affects the lives of individuals. While the U.S. government funds the Fulbright Program for approximately 1,300 international students a year, the proposal here is for a broader approach that becomes part of our foreign aid packages aimed at the developing world.

Some might argue that if an individual stays in America that is not really aiding that student's home country. That is not true. If the individual stays in America and becomes successful, he or she will likely maintain ties to his or her home nation, perhaps returning to invest in a business, as has been done by many successful Indian-Americans, such as Vinod Khosla and Raj Vattikuti. If the individual returns to that nation right after graduation to begin working in his native land, then we will have likely produced someone open and sympathetic to America who can serve as a window to our country for his or her fellow citizens.

## Conclusion

America remains a land of opportunity. It also remains a place where an individual can come, receive an education, and make a valuable contribution to our society. That individual may return to their native country and retain a positive impression of America as he or she rises in the ranks of business or government. That contribution may also mean staying in the United States after graduation and receiving a patent for a new technology, starting a business that creates jobs, or teaching U.S. college students at a major American university.

Obstacles remain that prevent the United States from significantly increasing the enrollment of international students at U.S. universities, particularly in graduate-level science and engineering programs. Policy improvements can be made in several areas that will ensure American leadership in international education and strengthen America's standing in technology, research, and education.

The door has not shut closed on international students. We still possess a window of opportunity to improve our policies and enhance America's standing as the place where one can come to study and learn. It is in our national interest that we seize this opportunity.

ENDNOTES

[i] After declining in 2002 and 2003, the number of F-1 student visas issued by the State Department increased 1 percent between 2003 and 2004.
[ii] *Policy Implications of International Graduate Students and Postdoctoral Scholars in The United States*, Committee on Science, Engineering, and Public Policy, Board on Higher Education and Workforce, Policy and Global Affairs, The National Academies, (National Academy of Sciences), Washington D.C., (prepublication copy), pp. 26-27. Hereafter referred to as the National Academy of Sciences report, 2005. Ibid., pp. 26-27.
[iii] *Open Doors 2004*, Report on International Educational Exchange, Institute of International Education, May 2005. Also, Peggy Blumenthal, "International Student Enrollment Trends: The U.S. Scene Within the Global Context," Institute of International Education, 2005, p 2, For a different perspective on the data see Robert Satloff, "The Brain Drain That Wasn't," *The Weekly Standard*, July 25, 2005.
[iv] A drop in applications does not in itself translate into a decline in enrollment, since it could reflect the same number of students deciding to apply to fewer universities. International student applications for U.S. graduate schools declined by 28 percent between 2003 and 2004 and a further 5 percent between 2004 and 2005, according to the Council of Graduate Schools. As cited in National Academy of Sciences report, 2005, pp. 26-27. In addition, 74 percent of schools reported level or declining enrollments for international graduate students at the start of the 2004-2005 academic year, according to a survey conducted by major U.S. educational organizations. Survey of Foreign Student and Scholar Enrollment and Visa Trends for Fall 2004, November 2004. The survey was conducted by NAFSA: Association of International Educators, the Association of American Universities (AAU), the National Association of State Universities and Land-Grant Colleges (NASULGC), the Institute of International Education (IIE), and the Council of Graduate Schools (CGS).
http://www.nafsa.org/content/PublicPolicy/forthemedia/enrollment_surveysummary.pdf
[v] National Academy of Sciences report, p.10.
[vi] Institute of International Education.
[vii] Interview with Robert Gelfond.
[viii] National Academy of Sciences report, p. 2.
[ix] Ibid., p.8.
[x] Richard Freeman, Emily Jin, and Chia-Yu Shen, *Where Do New U.S.-Trained Science-Engineering Ph.D.s Come From?*, NBER Working Paper No. 10554, National Bureau of Economic Research, June 2004, abstract.
[xi] Richard B. Freeman, "Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership?", paper delivered at Innovation Policy and the Economy Conference, April 19, 2005, Washington, D.C., pp. 5-6.
[xii] *Science and Engineering Indicators 2004*, The National Science Board, National Science Foundation, January 2004.
[xiii] Stuart Anderson, *The Multiplier Effect* in *International Educator*, Summer 2004; also available at www.nfap.com.
[xiv] *India Abroad*, July 15, 2005
[xv] Richard B. Freeman, "Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership?", p. 8.
[xvi] http://exchanges.state.gov/education/educationusa/leaders.htm.
[xvii] http://www.nafsa.org/content/PublicPolicy/stf/inamericasinterest.htm. See Executive Summary.
[xviii] *Financial Times*, February 7, 2005.
[xix] Stephen Yale-Loehr, Demetrios Papademetriou, and Betsy Cooper, *Secure Borders, Open Doors: Visa Procedures in the Post September 11 Era*, Migration Policy Institute, 2005, pp. 171-172.
[xx] "An Emerging and Critical Problem of the Science and Engineering Labor Force," A Companion to Science and Engineering Indicators 2004, The National Science Board, National Science Foundation, January 2004.
[xxi] As indicated, Susan Lin is not a single individual but composed based on the experience of other international students for the purpose of explaining the process and issues raised surrounding international student enrollment at U.S. universities.
[xxii] Due to the long processing times, many high-skilled individuals are hired first in H-1B (temporary) status prior to being sponsored for a green card.
[xxiii] Kyna Rubin, "China's Students; Turning Away of Staying Home, *International Educator*, Summer 2004, pp. 10-11.
[xxiv] *Open Doors 2004*, Institute of International Education, Table on Primary Source of Funding by Academic Level at http://opendoors.iienetwork.org.
[xxv] *India Abroad*, July 15, 2005.
[xxvi] Rubin, p.13.
[xxvii] Cornelius D. Scully, a former high-ranking State Department official in the Visa Office, provided much helpful information on the consular interview process.
[xxviii] "Extension of Validity for Science Related Interagency Visa Clearances," Office of the Spokesman, U.S. Department of State, February 11, 2005.
[xxix] National Academy of Sciences report, 2005, p.72.
[xxx] The law is the L-1 Visa and H-1B Visa Reform Act, passed on November 20, 2004.
[xxxi] The NAFSA strategic task force in its 2003 report did not specifically recommend a separate standard for international graduate students. Instead, it stated "Immigration laws affecting international students must be updated to reflect twenty-first century realities, particularly by replacing the unworkable 'intending immigrant' test set forth in section 214(b) of the

Immigration and Nationality Act with a standard that focuses on whether or not the applicant is a legitimate student." http://www.nafsa.org/content/PublicPolicy/stf/inamericasinterest.htm. See Executive Summary.

[xxxii] Interview with Catheryn Cotten.

[xxxiii] Richard B. Freeman, "Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership?", p. 5.

[xxxiv] "Jobs and Immigrants," *The Wall Street Journal*, Editorial, August 26, 2005.

[xxxv] Thomas Friedman, The World Is Flat, Farrar, Strauss, and Giroux, 2005, p. 273. Koon said, "People who graduate in these very technical fields that are critical to our industries should get a green card stapled to their diploma."

[xxxvi] Currently within the immigration policy realm, Citizenship and Immigration Services splits functions with Immigration and Customs Enforcement. The White House office of Science and Technology Policy becomes involved on major issues. The U.S. Department of Education appears to be a passive player that exerts little influence on even the most basic question of whether the United States should encourage increased enrollment of international students at U.S. universities. The State Department maintains consular offices that are separate, of course, from the work of the Bureau of Education and Cultural Affairs with regards to international student policy. The U.S. Department of Commerce also has interest in the issue.

[xxxvii] Interview with Marlene Johnson.

[xxxviii] Peggy Blumenthal, p. 3.

[xxxix] Daniel Obst and Joanne Forster, "International Students in the Context of the U.S. Higher Education System," Institute of International Education, 2005, p. 6. The legislation is H.R. 2601, the Foreign Relations Authorization Act for FY 2006 and 2007.

[xl] Senator Coleman's bills are the Opening Doors for Foreign Students Act of 2005, International Student and Scholar Access Act of 2004, and American Competitiveness Through International Openness Now Act of 2005.

[xli] The bill is H. Con. Res. 100.

[xlii] Daniel Obst and Joanne Forster, p. 8.

[xliii] Interview with Catheryn Cotten, Duke University; In America's Interest: Welcoming International Students, The Role of Higher Education, NAFSA and the Committee on Institutional Cooperation, White Paper from April 21-22, 2005 symposium at Indiana University. The task force also recommended exploring longer payment schedules for such students.

## Forum Attendees

**Mr. Stuart Anderson, Executive Director, National Foundation for American Policy**
**Mr. Eyal Aronoff, Founder, Quest Software**
**Ms Mariam Assefa, Executive Director, World Education Services, Inc.**
**Dr. George Atkinson, Science & Technology Advisor, US State Department**
**Dr. Frank Bean, Director, Center for Research on Immigrations, Population and Public Policy, University of California, Irvine**
**Mr. Randy Beardsworth, Acting Under Secretary, Department of Homeland Security**
**Ms Kathy Bellows, Assistant Dean and University Director International Programs, Georgetown University**
**Mr. Peter Briggs, Director, Office of International Programs, University of Michigan**
**Mr. Sam Castañeda, Advisory Board Member, National Postdoctoral Association**
**Dr. Phillip Clay, Chancellor, MIT**
**David Crane, Economic Policy Advisor to Governor Schwartzenneger**
**Mr. Roman Czujko, Director of Statistical Research, American Institute of Physics**
**Mr. Josh DeWind, Program Director, Social Science Research Council**
**Dr. Michael Drake, Chancellor, University of California, Irvine**
**Dr. Robert Dynes, President, University of California**
**Dr. William Fish, President, Washington International Education Council**
**Ms Julie Furuta-Toy, Executive Director, Office of Public and Diplomatic Liaison, US Department of State**
**Dr. Daniel Goroff, Vice President and Dean of the Faculty, Harvey Mudd College**
**Dr. Michael Gottfredson, Provost and Executive Vice Chancellor, University of California, Irvine**
**Dr. Laurel Haak, Study Director, Policy Implications of International Graduate Students and Post Doctoral Scholars in the U.S., National Academy of Sciences**
**Dr. Wendy Hall, Former Senior Policy Analyst, White House**
**Dr. Terry Hartle, Senior Vice President, Government and Public Affairs, American Council on Education**
**Ms Linda Heaney, President, Linden Educational Services**
**Ms Karen Hovorka, Global Recruiting Initiatives Manager, Accenture, Inc.**
**Ms Ur Jaddou, Senior Policy Advisor, Congresswoman Zoe Lofgren's Office**
**Ms Marlene Johnson, Executive Director & CEO, Association of International Educators**
**Mr. Marshall Kaplan, Executive Director, The Merage Foundations**
**Mr. Mike Lefkowitz, Program Director, The Samueli Foundation**
**Ms Jane Leu, Founder & Executive Director, Upwardly Global**
**Dr. Gene Levy, Provost, Rice University**
**Assemblywoman Carol Liu, Chair, California State Assembly Committee on Higher Education**
**Dr. Keith Maskus, Professor and Chair, Department of Economics, University of Colorodo, Boulder**
**Mr. Paul Merage, Founder and President of Falcon Investments and The Merage Foundations**
**Ms Joyce Monaco, Associate, The Merage Foundations**
**Mr. Michael Mussallem, Founder & CEO Edwards Lifesciences**
**Dr. Daniel Neuman, Provost, UCLA**
**Mr. Angelo Paparelli, Partner, Paparelli & Partners**
**Dr. C. Kumar N. Patel, CEO, Pranalytica, Inc.**
**Dr. Prem Paul, Vice Chancellor, University of Nebraska**
**Mr. Gary Rhodes, Director, Center for Global Education, Loyola Marymount University**
**Mr. Jack Rosenthal, President, NY Times Company Foundation**
**Ms Roselma Samala, Associate, The Merage Foundations**
**Dr. Henry Samueli, Founder & CEO Broadcom**
**Mr. Joel Slutzky, Chairman of the Board, Iteris, Inc.**
**Mr. Ted Smith, Founder, FileNet Corporation**
**Dr. Debra Stewart, President, Council of Graduate Schools**
**Dr. Tom Sullivan, Provost, University of Minnesota**
**Mr. David Von Damm, Assistant to Acting Under Secretary Randy Beardsworth**
**Dr. Patricia Wrightson, Director, Committee of Scientific Communication and National Security**