THE HAMILTON PROJECT
Advancing Opportunity, Prosperity and Growth

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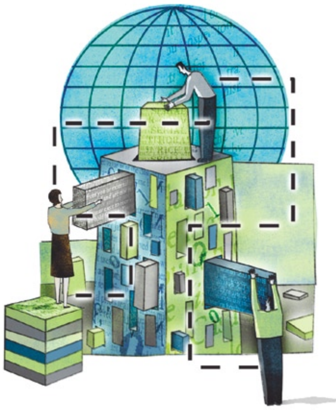
Investing in the Best and Brightest: Increased Fellowship Support for American Scientists and Engineers



THE UNITED STATES has long been the global leader in science and technology, and our ability to advance the scientific frontier has been a substantial source of our economic growth. In recent years, however, American dominance in science has dimmed as other countries have developed their systems of higher education and research and development.

Maintaining American economic leadership will require effective government policies that help the United States remain at the edge of the scientific frontier. In order to continue as a leading center of research, the United States not only must increase public investment in basic research, but also must ensure an adequate supply of scientific talent.

In a discussion paper released by The Hamilton Project, Richard Freeman of Harvard University proposes tripling the number of National Science Foundation graduate research fellowships, restoring the program's balance between awards given out and the number of science undergraduates. Freeman concludes that his proposal, which would cost about $375 million per year, would significantly increase the number of students who undertake graduate work in the sciences and engineering.

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THE CHALLENGE

By most metrics, the United States leads the world in science and technology. For instance, we lead in scientific output as measured by total articles published, number of citations, and share of frequently cited articles. In addition, a recent comparison concluded that thirty-eight of the world's fifty leading research institutions were in the United States; for decades these institutions have been the destination of choice for the world's best science and engineering students.

At the same time, progress by other nations has made the United States far less dominant in science today than it was thirty years ago. The U.S. share of world research and development (R&D) spending has been declining for decades: between 1990 and 2003, it fell from 40 to 35 percent. In addition, the U.S. share of worldwide science and engineering doctorates fell from 40 to 20 percent between 1970 and 2000, while the U.S. share of college students fell from 30 to 14 percent.

Freeman applauds the scientific progress made by other nations, noting that scientific advances abroad benefit the United States, just as our advances—whether in medicine or search technology—benefit people the world over. If a medical researcher in China or India were to develop a cure for cancer, we would all be grateful for and benefit from the spread of scientific excellence that gave rise to the cure.

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Nonetheless, despite the widely shared benefits of scientific research, Freeman argues that the United States would gain both economic and national security advantages from maintaining its position as the leading center of scientific and technological progress.

First, the growth of high-tech employment in Silicon Valley and other university-based locations of scientific excellence suggests that innovation, production, and employment in the high-tech sector occur largely in geographic areas that have a strong foundation in science. If major scientific advances are made in the United States, leading-edge industries are more likely to begin and grow here. These industries have the fastest productivity growth, pay higher wages to production workers, and offer spillovers of knowledge to other sectors.

Second, America's comparative advantage in trade lies in high-tech, research-intensive industries. Were the United States to lose its advantage in those sectors, it would have to sell goods or services on the global market that have lower technological content, causing us to gain less from trade. The United States needs top-flight researchers advancing the technological frontier to maintain our advantage in the face of growing scientific and technological capacity in China, India, and other developing countries. These countries will continue to have a cost edge in the high-tech as well as other sectors until their wages approach ours.

Third, national defense depends on a technically sophisticated military, and science and technology are a key component in our defense against terrorist threats based on chemical, biological, or radiological attack.

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Freeman argues that in order to remain a leading center of research, the United States not only must increase public investment in basic research, but also must ensure an adequate supply of scientific talent. Even as bolstering our nation's scientific base becomes increasingly important, however, university students in the United States have just maintained or even decreased their enrollment in certain critical areas such as engineering and the physical and mathematical sciences. Indeed, the United States now lags behind more than sixteen countries in Europe and Asia in the proportion of 24-year-olds with bachelor's degrees in the natural sciences or engineering (i.e., science degrees, exclusive of degrees in the social sciences). In 2002, 17 percent of undergraduates in the United States earned degrees in natural sciences and engineering, compared with 53 percent of undergraduates in China. Freeman estimates that by 2010 China annually will produce more science and engineering doctoral graduates than will the United States.

For those who choose to continue their education with a graduate degree in science, the time it takes to get the degree and to work in postdoctoral (or similar apprenticeship) roles has gradually lengthened. Although the time it takes to become a scientist has increased, however, the compensation in science and engineering fields has declined relative to other professional occupations.

Freeman notes that lagging student enrollment in science and technology need not result in a shortage of scientists and engineers. Currently, some of the most talented scientists and engineers working in the United States have come from abroad to work and innovate here, contributing to U.S. economic growth. Their numbers have risen in recent decades. In fact, there are many more highly skilled workers that would like to come to the United States than are permitted by U.S. policy.

Freeman argues, however, that the United States should strike a balance that allows the most highly skilled immigrant scientists and engineers to work and innovate in the United States, but that avoids an excessive reliance on their talent. Freeman suggests a number of reasons for the need to strike this balance:

First, our ability to attract the world's most highly skilled workers may decline as their native countries develop their own high-tech industries, offering opportunities to native scientists and engineers. Thirty years ago, most U.S.-educated doctoral science and engineering graduates from Taiwan and South Korea remained in the United States after earning their degrees; today, a large proportion of these graduates return to their native countries following completion of their programs. Although the United States retains large numbers of Chinese and Indian students, those numbers are likely to decline as China and India develop their economies and increase opportunities for native students.

Second, our access to high-skilled immigrant scientists and engineers could be limited by changing political or security concerns—a risk that became more salient after September 11, 2001. Since those events, the United States has imposed significantly tighter visa restrictions on international students. Similarly, political factors may limit the willingness of international students to come to the United States.

Key Highlights

The Challenge

- In an era of increasing globalization, maintaining U.S. leadership in science and technology will spur the growth of new industries and new jobs and provide important national security benefits.
- Maintaining U.S. leadership in science and technology requires that we both increase public investment in basic research and ensure an adequate supply of scientific talent.
- In the early 1960s, NSF granted about one thousand graduate research fellowships a year. Today, despite a more-than-threefold increase in the number of college students graduating in science and engineering, the NSF grants the same number of fellowships.

A New Approach

- To enhance the supply of U.S. citizens in science and engineering professions, the number of NSF graduate fellowships would be tripled, and the value of the fellowships would be increased from $30,000 to $40,000 per year.
- The proposal would cost about $375 million per year; evidence from prior changes in the NSF fellowship budget suggest that this proposal would significantly increase U.S. graduate enrollment in science and engineering.
- To be effective in the long term, increased fellowships must be coupled with greater federal support for R&D generally and for young, post-doctoral scientists in particular.

Third, security considerations require that only U.S. citizens perform research within some Department of Defense laboratories and the National Security Agency. As a result, the United States needs an adequate supply of highly skilled science and engineering doctoral graduates who are U.S. citizens to work in those restricted facilities.

Freeman argues that the best way to increase the share of U.S.-born scientists is to encourage bright young Americans to go into science, rather than to discourage scientists from other countries from working here.

A NEW APPROACH

To increase the supply of talented U.S. scientists and engineers, Richard Freeman proposes that the National Science Foundation (NSF) triple the number of graduate research fellowships (GRFs) for science and engineering work, and increase the value of those awards from $30,000 to $40,000 per year. Together, these changes would cost about $375 million per year.

If enacted, these changes would represent the second major improvement to NSF GRFs in less than a decade. In 1999, the NSF's Committee of Visitors noted that "the GRF awards are no longer as attractive as they once were" and recommended that the stipend value be raised from $15,000 to $18,000 per year. NSF went much farther, raising the value of the stipend to $27,500 in 2002 and to $30,000 in 2005, but it did not increase the number of awards. Following these changes, the number of NSF applicants as a share of all bachelor's degrees in science and engineering nearly doubled (but no more fellowships were given out).

Even with these recent changes, however, current NSF GRF policy offers less incentive for young students to go into science and engineering research than it did in the early 1960s. Today, NSF gives approximately the same number of GRFs as it gave then, when the United States had less than one-third the number of undergraduates receiving degrees in science and engineering than it does now. Tripling the number of NSF GRFs would roughly restore the ratio of GRFs to undergraduate science and engineering degrees that prevailed four decades ago. It would send a dramatic signal to American students that the country wants them to specialize in these areas.

Freeman argues that providing a larger number of higher-valued GRFs would affect the decisions of potential scientists for two reasons. First, GRFs represent a large proportion of discounted lifetime earnings, particularly since they come early in a scientist's career. Second, GRFs signal to recipients (and employers) that they have the talent to have a successful career in the sciences. These incentives could influence more than the number of people who actually win fellowships; as more GRFs become available, more students will apply to graduate school.

To assess the potential impact of these changes, Freeman examines the relationship between the budget for NSF GRFs and the percent of college graduates pursuing advanced degrees in science and engineering. Using historical data, he estimates that a 10 percent increase in the NSF fellowship budget increases U.S. graduate enrollment in science and engineering by 7 to 15 percent. His proposal to more-than-triple the NSF fellowship budget would have a much larger effect.

Freeman notes that there are many highly qualified candidates who do not currently receive GRFs. Freeman examines the qualifications of applicants who do not currently receive awards and finds that they have records that are insignificantly different from those of awardees. As a result, the number of awards can be greatly increased without reducing the quality of NSF fellows, especially since the value of the awards will be increased.

> "The number of National Science Foundation graduate research fellowships has remained virtually unchanged since the early 1960s, despite a three-fold rise in the number of science and engineering bachelor's degrees awarded each year."

To be sure, NSF is not the only government agency that awards fellowships for graduate study, but it is the largest. Of the 7,301 graduate students who received fellowships from the federal government in 2003, approximately 3,300 received their award from NSF. Moreover, NSF GRFs are particularly well suited to Freeman's goal of building overall U.S. capacity in science and technology. In contrast to fellowships given by other agencies, NSF GRFs are distributed across the various scientific disciplines according to the number of qualified applicants in each field—if more top-notch physicists apply in one year, the number of physics GRFs will go up—and not according to predetermined quotas. They are thus the only awards that allow the market, through students' choices, to determine the fund-

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ing made available to different scientific fields. Freeman emphasizes that his proposal will lead to an increase in the permanent base of scientific talent only if complementary policies are implemented as well. Freeman notes the pressing need to create greater career opportunities for young researchers after they finish graduate school. Possible new programs include special awards for young scientists and engineers, or increased fellowship support for postdoctoral fellows so that they need not rely so heavily on principal investigators for research funding. In addition, overall R&D spending must rise in order to increase the demand for scientists and engineers.

Implementation Questions

Will increasing the number of NSF fellowships change the total supply of scientists? One might question how much of a difference an increase in the number of NSF GRFs can make, since NSF GRFs support a minority of graduate students. Freeman's research, however, suggests that there is a strong relationship between the NSF GRF budget and the number of students enrolled in graduate science programs. There are a number of possible explanations. First, since NSF GRFs operate as a prize, the prospect of winning one may pull many more undergraduates than actually win one to apply for the fellowship—and simultaneously to apply for graduate school. Second, other stipend providers, such as universities, foundations, and agencies, may increase their spending in line with NSF increases, though since most of the funding increase for this proposal comes from more, and not larger, fellowships, this may play less of a role than with prior NSF GRF spending increases.

Additionally, it is not just the number of scientists that is important. Since the work of top researchers can have such dramatic benefits for the rest of society, there is a likely benefit to be had from attracting the best students into science, even if the total number of scientists remains relatively unchanged.

Why not improve K-12 science and math education instead? Freeman argues that improving science and math education from kindergarten to grade twelve (K-12) can have significant benefits, but that such improvements should be considered a complementary strategy, not a substitute for increasing the number and size of NSF GRFs. First, investments in young students would take fifteen to twenty-five years to affect the supply of scientists and engineers, so they would not solve the short- to medium-term problems. Second, because K-12 investments would be spread over the entire U.S. public school population, most of whom will never consider careers in science and engineering, such investments probably would be less cost effective than the proposed fellowship program, which spends its resources only on highly able students who have demonstrated an interest in graduate science programs.

CONCLUSION

Because innovators capture only a small fraction of the benefits that their inventions provide to society, the private sector will invest less in R&D than is justified by its benefits to society as a whole. As a result, society can benefit enormously from public investment in scientific research and the educational systems that make such research possible. Today, while excellent research is being done in the United States, less of it is being done by U.S.-born scientists, while at the same time our role as the world's scientific leader is being challenged.

In 1957, faced with the Sputnik challenge from the Soviet Union, the United States responded with increased R&D spending and large numbers of National Science Foundation Graduate Research and National Defense Education Act fellowships. Together, these policies induced large numbers of young Americans to invest in science and engineering careers. In the early 1960s, NSF granted about one thousand GRFs a year. Today, despite a more-than-threefold increase in the number of college students graduating in science and engineering and a concurrent global challenge from the spread of technology and higher education to the rest of the world, the United States grants the same number of NSF GRFs. Richard Freeman's research suggests that returning the NSF GRF program to its post-Sputnik proportions, while also investing more public funds in basic research, would be a highly efficient way to increase American scientific output and raise the share of that output that is performed by American citizens.

Learn More About This Proposal

This policy brief is based on the Hamilton Project discussion paper, *Investing in the Best and Brightest: Increased Fellowship Support for American Scientists and Engineers*, which was authored by:

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Additional Hamilton Project Proposals

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  Technological progress has accounted for a large and increasing share of U.S. economic growth. The Hamilton Project's strategy calls for strong new policies in the areas of education, research and development, and intellectual property.
- **Aligning Patent Presumptions with the Reality of Patent Review: A Proposal for Patent Reform**
  This reform proposal is designed to reduce both the incentive to file undeserved patent applications and the harm caused by wrongly issued patents.
- **Prizes for Technological Innovation**
  Because the federal government now funds scientific research primarily through grants or contracts, it must choose both the researchers and the research approaches that it wants to support. Prizes would allow the government to set goals without determining the best person or method for reaching those goals.

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The Project is named after Alexander Hamilton, the nation's first treasury secretary, who laid the foundation for the modern American economy. Consistent with the guiding principles of the Project, Hamilton stood for sound fiscal policy, believed that broad-based opportunity for advancement would drive American economic growth, and recognized that "prudent aids and encouragements on the part of government" are necessary to enhance and guide market forces.

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