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**Article**

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NBER Reporter Online

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National Bureau of Economic Research (NBER), Cambridge, Mass.

*Suggested Citation:* Freeman, Richard B. (2007) : The market for scientists and engineers, NBER Reporter Online, National Bureau of Economic Research (NBER), Cambridge, MA, Iss. 3, pp. 6-8

This Version is available at:

<https://hdl.handle.net/10419/61905>

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# The Market for Scientists and Engineers

Richard B. Freeman\*

The job market for scientists and engineers has moved to the forefront of national policy concerns for the first time since the launching of the Sputnik satellite in 1957. Diverse business, education, and science groups have issued Cassandra-style reports on the state of U.S. science and engineering. The most prominent of these, the National Academy of Science's "Rising Above the Gathering Storm" (2006), suggested that the United States risked losing its leadership in science and technology, with dire consequences for the economy and for national security; the report called for increased R and D spending and new policies to attract more young Americans into science and engineering careers. Concurring with these assessments, President Bush in his 2006 State of the Union Address announced the American Competitiveness Initiative to "ensure a continuous supply of highly trained mathematicians, scientists, engineers, technicians, and scientific support."

My recent research on the science-engineering job market has focused on exactly what has generated the widespread worry about the market for scientists and engineers and what changes in the career prospects for scientists and engineers might insure future supplies of such workers.

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## What! Me Worry?

Concerns about the science and engineering job market are not rooted in a classic labor market shortage. The earnings of scientists and engineers are not rising rapidly, relative to other highly educated workers. There are no massive job vacancies in academe, business, or government. If rapidly rising pay is the primary signal of a market shortage, then the United States has a shortfall of CEOs, professional athletes, entertainers, and hedge fund managers, not scientific and engineering specialists.

The number of science and engineering workers in this country has increased at an annual rate of 2.7 percent — which far exceeds the rate of growth of the work force. The number of bachelors and masters graduates in the fields has trended upward. The supply of Ph.D.s in science and engineering has roughly stabilized at about 28,000 per year, more than enough to keep the stock of Ph.D. specialists rising.

Why then is the leadership of the country so worried about the market for scientists and engineers? One reason is that the United States is losing its dominance in science and engineering. The U.S. share of the world's science and engineering students and employees in the world is falling. So too is the country's share of R and D, papers and citations in scientific journals, and high tech exports. But with just 5 percent of the world's population, it is impossible for the United States

to maintain the 35 percent to 45 percent share of science and engineering activity that it had at the end of the twentieth century. The rest of the world has invested in higher education and R and D. The European Union has rebuilt and expanded its university system. In 2001 it graduated 50 percent more Ph.D.s in science and engineering than did the United States and it is on track to double the number of U.S. graduates in 2010. China, India, and the ex-Soviet bloc have joined the global economy, greatly increasing the number of young persons choosing science and engineering careers. In response, the multinationals that do much of industrial R and D have begun to locate research facilities in those countries, as well as hiring specialists from the global talent pool for work in the United States. Today and into the foreseeable future, more and more specialists in different countries will be adding to the stock of useful knowledge and will enable the world to make better goods and services. Some will do their work in the United States, but many will not.

As other countries become more competitive in knowledge production and in its application to the economy, the United States will lose its comparative advantage in high tech and see the gains from that trade diminish. Some fear that this will harm U.S. workers. One of the selling points of NAFTA was the promise that trade meant good jobs for Americans and menial jobs for workers in developing countries. The North-South or product life-cycle models of trade and tech-

nology predict such an outcome. These models assume that the United States (other advanced countries) has large supplies of scientists and engineers that give them a monopoly on R and D and new technology. U.S. wages are higher than those of otherwise comparable workers elsewhere because they work with the new technology. The faster the rate of the technological progress relative to the rate of diffusion of technology to developing countries, the higher are wages in the United States.

In a world in which highly populous, low income China and India invest heavily in higher education, this model no longer represents reality. The quantity and quality of scientists and engineers in those locales, and in other low-wage countries, as well as in advanced Europe and Japan, has increased. To the extent that production follows the R and D, the spreading of science and engineering reduces the first mover advantages that U.S. workers once had in production and thus their competitiveness in the global economy.

Another reason for concern relates to national security, since it is the technological superiority of the U.S. military on which the country's defense largely rests. If foreign countries can compete in R and D, they may be able to compete in military technology, as the Soviet Union did years ago.

Competition among countries aside, there is another reason for the concerns about the state of science and engineering in the United States. Because the United States is the lead country on the technological frontier in many industries, the various groups believe that it must keep advancing that frontier to maintain productivity and that U.S. R and D has failed to keep pace. To the extent that the social return to R and D exceeds the private return, particularly for basic science, the country is missing a chance for economic growth.

The long-term level of expenditures on R and D relative to U.S. GDP has stabilized at around 2.6 to 2.7 percent of GDP. Industry has increased its share of spending from about one third in the 1960s to nearly two thirds in 2006. The

concern thus is about the failure of federal funding to keep pace with the growth of the economy. Many complain about a reduced time horizon and narrowing of the focus of R and D when global warming and rising energy prices suggest the need for greater basic research spending.

But the problem with federal spending goes beyond dollar amounts. The U.S. government greatly expanded its R and D spending in two areas in the past decade. Between 1996 and 2002, it doubled spending on the National Institute of Health. And beginning in the 2000s, it has increased spending substantially on nano-technology. The NIH spending might have been expected to create a boom in the job market for bioscientists, but it did not. Most of the research awards went to senior scientists, who hired graduate students and newly minted Ph.D.s from the United States and overseas to work as post-docs in their labs. The chances that young scientists would gain a grant on their own fell to negligible proportions. And, with universities hiring few new tenured faculty members, the chances for post-docs to move into independent research positions dropped as well. With NIH spending no longer increasing, the increased number of post-docs has created a market glut and dissatisfaction among scientists who cannot get research projects funded.

Finally, some of the concern about scientists and engineers has been linked to a huge change in the demographic composition of U.S. supplies. In 1966, 71 percent of Ph.D. graduates were U.S.-born males, 6 percent were U.S. born-females, and 23 percent were foreign born. In 2000, 36 percent of graduates were U.S.-born males, 25 percent were U.S.-born females, and 39 percent were foreign-born. In the 1990s, the United States roughly doubled the foreign-born share of its science and engineering work force. The ability of the United States to attract highly able foreign-born students and immigrant scientists and engineers reflects on the excellence of U.S. higher education and the work environment. But huge increases in supply make these careers less attractive to the native-born.

## The Supply Curve is Positively Sloped

To investigate the role of supply incentives on the decision to invest in a science and engineering doctorate, Tanwin Chan, Hanley Chiang, and I have examined data on the 200,000 or so applicants to the National Science Foundation's highly prestigious Graduate Research Fellowship Award (GRF) from the program's inception in 1952 to 2004. We analyzed the determinants of the number and characteristics of applicants and winners of the GRF. Since the award provides financial support for graduate studies and signals top students that they have the appropriate skills to undertake graduate training, it can affect career decisions to enter science or engineering or to go to other high-level occupations. If the United States wanted to increase the number of citizens doing graduate work in these fields, and if students responded to the incentive of the rewards, then the GRFs would be a valuable policy tool to deal with the concerns

The first important thing that we learned about these awards is that the United States gave approximately the same number—1,000 or so—in the 2000s as it gave in the 1960s, when there were only one third as many Bachelors of Science graduates per year. This meant that science and engineering graduates with bachelors' degrees had a much lower chance of getting an NSF grant than 40–50 years ago—an unintended negative signal to students about the value the country places on scientific and engineering careers.

Our analysis also found huge variation in the dollar value of the awards relative to the level of prices and to the earnings of college graduates over time. In 1999 the NSF decided that the awards had lost economic attractiveness; it doubled their value over the next five years to \$30,000. The supply response of students in terms of the number of applicants was in turn huge, nearly doubling as well.

We estimated supply responses to the number and relative dollar value of NSF awards in various ways. Since we did not know what "alternative" careers the appli-

cants for NSF awards might be considering, or indeed if applicants who do not get an award will go on in science, our favored measure was a simple figure that linked the proportion of grant applicants to Bachelor of Science graduates, to NSF spending on GRFs, and finally to GDP—the relation was remarkably tight. In addition, when the value of the award went up, the NSF got enough top applicants that it was able to choose nominally better candidates (in terms of GRE scores, for instance).

What about the determinants of who wins an NSF award? We examined the field, gender, racial composition, and undergraduate college of GRF applicants and recipients over time. In the early years of the program, the awards went largely to white men in physical sciences and mathematics, but increasingly over time large proportions have gone to students in the biological sciences, social sciences, and engineering, and to women and minorities. Indeed, in 2004 over half of the recipients of the awards went to women. Our analyses showed that GRE scores, grades, and the quality of undergraduate institu-

tions affected the probability of winning an award. We also found that there were many applicants who did not win the awards whose measured skills were only marginally lower than those of the winning applicants. This is consistent with the notion that there is a substantial supply of able students on the margin of science and engineering, if the country were to increase the number of awards.

## Conclusions

Given the attraction of the United States as a place to work for scientists and engineers, the potential that the country will experience a genuine labor market shortage seems remote, barring some dramatic closing of our borders. If the United States increases R and D spending, as recommended by many of the business, education, and government committees, then the demand for scientists and engineers will increase. My research indicates that any increase in demand can be met by increases in the supply of young Americans through improved stipends for graduate students and by continuing to

attract foreign-born students and specialists to the country.

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