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Short-Changing Our Future

America's Penny-Wise, Pound-Foolish Approach to Supporting Tomorrow's Scientists

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It may be an old refrain, but the future of American scientific and technical research is in jeopardy. Over the past decade, there has been a steady decline in the share of U.S. citizens receiving advanced degrees in science and engineering, as well as a flight of many of the best and most motivated American scientists from key fields of basic research.

These trends are quite troubling. Modern American prosperity is derived largely from technological innovation, as evidenced by the massive contribution of the communications and computer-equipment sectors to the growth of national productivity.

From 1980 until 2003, for example, production of high-tech goods grew 6.4 percent, as opposed to a rate of 2.4 percent for other wares. Even after the bursting of the "tech bubble," high-tech manufacturing growth outpaced other categories by more than fourfold.[1]

The most important technological innovations leading this growth—including the development of fiber optics, the transistor, and the laser—have relied heavily upon fundamental research in quantum mechanics, solids, and optics. This linkage between basic exploratory research and technological innovation is ubiquitous and widely recognized as vital to the future of the American economy.

The role of basic science in determining the strength of national economies will only become greater in the future. Emerging high-tech sectors such as nanotechnology, biotechnology, and clean energy build upon fundamental research that requires advanced education and extensive infrastructure investments.

Yet U.S. industry is investing less and less in basic research and development (R&D). As a percentage of sales in industry, R&D has been falling since 2000, but more importantly, industry contributed only 4 percent of its R&D budget to the basic research that drives future breakthroughs.[2]

In an economic landscape dominated by the need for short-term capital returns, the immediate incentive to sustain large commercial research centers simply does not

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exist, as evidenced by the recent demise of Bell Labs. These outposts of learning have been crucial to American technological advancement, and the reduction of their role is not a propitious sign.

To make matters worse, the shift in research towards infrastructure-intensive fields has limited the ability of small businesses to meaningfully contribute to exploratory research. The amount of federal research and experimentation tax credits filed since the dot-com bubble burst—credits aimed largely at incentivizing small-business participation in research—has declined from $7.1 billion to $5.5 billion.

In the face of an insufficient corporate-sector commitment to basic research, where should we turn? Our nation also relies upon the technical education, training, and infrastructure provided by academic research centers, based in this nation's university labs. Academia has provided both a critical mass of scientific talent and the experimental infrastructure needed for the realization of new technologies.

More than 60 percent of academic researchers identify their pursuits as "basic research,"[3] a figure unmatched in other sectors. Overall, universities and colleges perform 56 percent of all basic research nationally[4] and remain the most important training centers for future generations of scientists and engineers. Academia, simply put, is an engine for innovation and a resource ensuring future technological competitiveness.

Unfortunately, our nation is failing to invest sufficiently in the training and support of academic researchers—the men and women who in some respects hold our future economic vitality and national security in their hands.

It is no exaggeration to say that the economic position of the academic scientist in the United States is weak enough to produce a significant threat to future U.S. competitiveness. However, by improving economic incentives for academic researchers, we can ensure that U.S. policy remains conducive to innovation.

Specifically, this report proposes that the federal government address this problem in two ways:

First, focus federal dollars on supporting the actual costs of graduate and postdoctoral students, rather than simply defraying university overhead costs. This step alone could save up to $2 billion a year that would be better spent on pay raises for academic researchers.

Second, we should raise the federal investment in academic research salaries by approximately $2 billion per year through an expansion of research fellowship programs. Combined with the reduction in overhead payments, this step could create incentives for more young people to embark upon academic research careers by allowing universities to offer significantly more generous fellowships to U.S. researchers.

Financial Disincentives for Academic Researchers

It may seem self-serving for a scientist to offer a technology policy centered on better pay for scientists. However, once a picture of the costs and (limited) rewards associated with careers in the field are laid out, the need for a change in how research scientists are remunerated will be self-evident.

As an illustration of the obstacles presently facing a young American weighing a career in scientific research, consider all that is required to obtain a Ph.D. in physics, a discipline reasonably representative of academic science in general.

The median time to completion of a Ph.D., after four years of undergraduate education, is six years, with 25 percent of candidates requiring more than eight years to complete the degree. This has yielded a median age at degree conferral of 30.4 years, according to the government's annual Survey of Earned Doctorates.[5]

Aside from one or two years of classwork at the beginning of the program, the remainder of the time spent earning a physics Ph.D. is devoted to full-time research. At this point, the students are no longer really in school—they are highly skilled labor for universities. However, these students are generally expected to work far in excess of a full-time commitment, for a salary of about $25,000 per year.[6]

One might argue that this is not such a bad deal, considering that the student is now receiving a salary rather than paying tuition. However, it's important to focus on the fact that in this situation the university has access to superbly trained labor and pays a pittance for it.

Seen from another perspective, this phase in a student's career may be regarded as on-the-job training, and receipt of this training should not diminish the fact that the researcher should be paid a fair market value for the work they perform.

What are the economic prospects for these students once they complete their degrees? Typical physics researchers, after receiving a Ph.D., go on to spend between two and five years in postdoctoral research. This is not just "supplemental training," as some would suggest; many academic departments require postdoctoral research in order to be considered for faculty positions. The National Science Foundation estimated that as of 2003, 48 percent of all science and engineering Ph.D. recipients employed by research universities were in postdoctoral research positions three years after receipt of the degree. During this period, they earn a typical salary of about $40,000 per year in physics departments.[7]

That is not a poor salary by nationwide standards, but nor is it a salary commensurate with the educational attainment of a postdoctorate researcher. According to the Census Bureau,[8] such a salary places an academic postdoctoral researcher at approximate parity with workers outside academia who have "some college" or an associate's degree.

More disheartening, perhaps, is the fact that researchers often have a financial incentive to stop short of the highest degree in their field. A physics major who enters the nonacademic workforce after completing a bachelor's degree reports a median annual salary of $41,000,[9] which, as we have just seen, would place him or her at the high end of the range of typical starting salaries for postdoctorate researchers. A master's degree recipient in physics can expect a median starting salary outside of academia of about $55,000. [10]

This pay gap is not unique to the physical sciences. Another area of national economic interest, life science, shows similar trends. A National Science Board publication showed that median real salaries for college graduates with life-science majors increased 24.5 percent from 1993 to 2003, while over the same period doctoral salaries across all life-science sectors rose by a mere 0.3 percent. The median salary across all life-science employment within five years of receipt of the doctoral degree was just $39,000 per year, the lowest of all science and engineering disciplines.[11]

Perhaps these low salaries may all be accounted for as paying one's dues on the way to a rewarding and lucrative career as an academic professor. Unfortunately, once again this perception is deeply flawed. Even for those fortunate enough to land a coveted tenure-track faculty position, the median academic starting salary in the physical or life sciences is only $50,000 per year, again less than a master's degree recipient can command outside of academia.[12]

Of course, many top academic researchers at high-profile institutions eventually do much better than this, but pursuing an academic career in science can easily push the point at which one receives an inarguably decent and stable salary to beyond age 40.

In other words, a scientific research career often requires huge personal and financial investments and simply does not pay out in a manner commensurate with its demands. It is no wonder that our society is failing to generate the technical expertise it needs to remain at the leading edge of competitiveness.

The Impact on Scientists

Not everything is about money, but it should come as no surprise that many bright and motivated individuals who look closely at the economic return on an academic-track scientific education are deciding to take a pass.

They might look at potential starting salaries for MBA recipients, for example, and opt to abandon their undergraduate science studies (or even their Ph.D. programs) and go to business school instead. After all, average starting base salaries for MBA recipients in 2006 exceeded $92,000,[13] with over $17,000 in signing bonuses.[14]

For many of the best students today, the lure of higher pay in alternate sectors is proving too tempting to resist, even if their passions truly lie in science. These young men and women, educated in science and engineering, are bypassing careers in science. Their resulting financial gain is America's scientific loss, leaving the nation with a basic-research community that is older, sparser, and less talented than it should be at a time when the nation's future prosperity depends on the sustenance of a deep scientific talent pool. The National Science Board has found a consistent aging of the academic doctoral research community and a decline in the proportion of doctorate-level researchers joining academic institutions, suggesting that this flight may be having a significant impact.

Foreign Researchers Filling the Vacuum

Our nation's academic research positions are being filled, but the scholars filling them are increasingly likely to be non-U.S. citizens. Between 1973 and 2006, the share of foreign researchers in U.S. graduate programs has grown from 11 percent to more than 45 percent, with fully half of all doctoral degrees in physical, life, and engineering sciences in 2006 being awarded to non-citizens.[15]

Meanwhile, the number of American citizens receiving doctoral degrees in these crucial fields remained flat from 1997 to 2006;[16] thus, the 16 percent increase in doctoral degrees awarded during that period is attributed exclusively to researchers from other countries.[17] As of 2003, 57 percent of postdoctoral researchers in the physical sciences were foreign nationals, as were 63 percent of those in engineering.[18] The expanding role of foreign researchers and grad students in the U.S. bespeaks a troubling weakness in our own scientific base.

The arrival of foreign nationals in the United States to pursue their studies and subsequently drive innovation in America is, on balance, a positive development. However, there is the increasing tendency of foreign nationals to pursue their studies in the United States, only to return to their home countries and pass the economic and security-related rewards of their endeavors on to other nations. China, Taiwan, Korea, and Ireland have put in place a variety of incentive packages for scientists studying abroad to return home and subsequently serve as instruments of economic development in those nations.[19] Such a distribution of talent—and the resulting expansion of prosperity abroad—is a welcome development in many ways, but coupled with the decline in U.S. interest in basic research fields, this trend represents a significant threat.

In addition to the economic motivations for maintaining a robust domestic research population, national-security considerations also arise here. One such consideration is the role that academic researchers play in setting policy and assisting with sensitive national-security projects. Such projects are understandably closed to foreign nationals, and a decline in the available talent pool of U.S. scholars is an ominous portent for the future of our technical security and superiority.

With these challenges in mind, it is vital that the United States offer incentives to our best and most talented students—those arguably most likely to select more lucrative professional avenues—to pursue careers in basic and fundamental research.

Tackling the Pay Gap

There is a straightforward solution to the dwindling supply of U.S.-born academic researchers: Raise the salaries of graduate students, postdoctoral fellows and junior faculty members in order to attract the best and most motivated scientists to the field.

This is not a completely novel idea. In a report titled "The Science and Engineering Workforce: Realizing America's Potential," the National Science Board recognized that scientists are often called to other professions, or to more lucrative positions in the large industrial R&D sector.[20] The report specifically called for new initiatives to ensure that graduate and postdoctoral stipends are "competitive" with alternative opportunities.

It would not be practical to raise graduate and postdoctoral salaries to anything approaching parity with those available in the financial industry. But if a graduate student in the "hard sciences" could expect a salary at least commensurate with what the average undergraduate science major can garner in the job market, the sacrifice associated with the length and rigor of the Ph.D. program would be at least partially offset.

Similarly, at the post-doctoral level, providing starting salaries that are at least competitive with private-sector jobs requiring comparable levels of education (about $70,000 annually) could help stanch the flow of top scientific researchers to careers in other sectors.

How much would such incentive packages cost? According to the 2007 Survey of Earned

Doctorates, approximately 22,000 doctoral degrees were awarded by U.S. institutions in mathematics and in the physical, life, computer, and engineering sciences.[21] Of these, approximately 50 percent went to U.S. citizens. At $50,000 each per year ($40,000 salary plus tuition and fees), this would total an annual expenditure of $3.3 billion for doctoral students in vital scientific and technological subjects. Similarly, assuming all such students continued on for a two-year postdoctoral research position at an annual cost of $100,000 ($80,000 salary plus fees), costs would total approximately $5.5 billion per year.

The federal government already pays for 63 percent of all academic research funding, while institutions account for approximately 19 percent, and the remainder is derived from industrial collaborations; state and local governments; and private foundations.[22] Federal funding vehicles include a limited number of graduate and postdoctoral fellowships, but overall, academic researchers are heavily reliant on funding from federal research grants and contracts awarded to primary investigators.

This support structure for academic researchers—salaries predominantly derived from federal grants and contracts—is not an optimal solution. Universities charge overhead on government grant and contract funding. Fellowships are generally administered in such a way that they do not incur these costs. The overhead rate varies by institution, but can exceed 50 percent of any charges against a given funding vehicle for many private universities.

Hence, a typical graduate student earning $20,000 a year under a research assistantship funded through a research grant can cost the government $60,000 or more at major research institutions, including tuition and overhead costs, while a $40,000 postdoctoral researcher can cost approximately $100,000 per year.

A back-of-the-envelope calculation suggests that the federal government is already spending in excess of $3 billion annually on academic research-personnel support, and of this amount, approximately $1 billion per year goes to university overhead rather than actual personnel support.

These costs are not wholly illegitimate, but they do tend to discourage salary increases, since the percentage paid to overhead on top of a given charge is constant.

Universities, of course, will resist any reduction in overhead payments, but the long-term gains associated with increasing the quality of their graduate and postdoctoral talent pools will more than offset such costs. The reduced overhead income for universities could be covered by spending from endowments—currently a hot topic as endowment gains have skyrocketed while university spending as a proportion of endowment value has dropped. This consideration is especially relevant in light of the strong correlation between a university's federal research funding and its endowment size.

However, even if the federal government increased research funding by $3 billion per year to offset the research costs addressed by overhead charges, this would amount to approximately 2.6 percent of the fiscal 2007 federal obligation for all R&D expenditures,[23] the equivalent of the costs of about one week of our military presence in Iraq.

Of course, it should not be assumed that anyone who wants to earn an advanced degree is automatically entitled to fully competitive financial support. Academia in the United States remains a meritocracy, and competition for funding would be the right mechanism for allocating research fellowships—though such fellowships should in any event not be as scarce or as stingy as they are today. With stronger incentives, the United States can dramatically improve the attractiveness of scientific research as a career. The future economic growth and competitiveness of our nation may well depend on it.

Endnotes

1 Science and Engineering Indicators, 2006, National Science Foundation: National Science Board, 2006.

2 Science and Engineering Indicators, 2008, National Science Foundation: National Science Board, 2008.

3 *Ibid.*

4 *Ibid.*

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9 National Science Foundation, *SESTAT - Scientists and Engineers Statistical Data System*, *http://sestat.nsf.gov*.

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