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*"How Economics Shapes Science?"*

# RESUME

There is considerable evidence that research contributes to economic growth. It has brought new efficient drugs and linked behaviors to health outcomes, so that life expectancy has increased by 14 years in the last 70 years. Fundamental research in information technology has given us innovative products, such as integrated circuits, the Web and modern capacity hard drives that also have fostered growth. Much of the research that eventually stimulates growth is initially supported through public funds although it is important to recognize that this research is not sufficient for growth: industry plays an absolutely crucial role, as well. Given the long lags between scientific inquiry and economic impact, policies that affect public research today will have an impact for many years to come. It is thus critical to use research funding more efficiently, even more so in times of austerity. Scientific research can be expensive, and costs as well as incentives affect the practice of science. I will explore how public research organizations and scientists respond to incentives and costs, and how this is enhancing or hindering productivity. Although the U.S. academic R&D system is often held up as an example, it also has some worrying flaws, as I will discuss.

Universities and medical schools perform about 75% of research that is published in the US. In universities, research is organized around faculty members' labs. The university gives faculty money for three years, and after that they are on their own to get funding for their labs from external agencies. Also, faculty salaries are for nine month, so in most universities, faculty members have to find some support for their own salary, and buy out some of their time on research grants. The majority of grants in the US are for three to five years, which means faculty are almost always in the process of getting or renewing grants. Faculty in "soft money" positions must support themselves entirely off the grants.

American universities receive 55 billion a year for R&D; 60% of this comes from the federal government. Much of this is distributed through peer-review. Over a half of these governmental funds comes from the National Institutes of Health (NIH), which has 27 institutes — the largest being the National Cancer Institute (with a budget of about 6.5 billion dollars a year), Allergy and Infectious Diseases, Heart, Lung and Blood, and General Medicine (2 billion-dollar budget), that supports the most basic research coming out of NIH. The National Science Foundation plays a much smaller role, with 10%, before Defense, Energy and NASA. Between 1998 to 2003, the Clinton

administration doubled the NIH budget in nominal terms, to reach 28 billion dollars in 2003.

NIH provides funds for staff, graduate students, post-docs, faculty salary, equipment, material and indirect costs. The most common of these grants is called an RO1. Historically, only 50% of the submitted proposals were discussed, commented on and scored by assigned “study sections”. NIH then determines what is called a payline which determines which ones will be funded, and then the projects are reviewed by a General Council that meets three times a year. Reviewers attach considerable weight to preliminary data, publications and academic lineage. The success rates have been from 10% to 40% depending on how much money the government has, and it varies by time and by institute. Scientists may also apply for renewals of successfully funded projects. Most scientists regularly resubmit. A renewed application has a much higher probability of being funded, and it’s not uncommon to be supported on the same grant for forty years. The Howard Hughes Medical Institute has long supported people rather than projects and thee Wellcome Trust recently adopted a similar approach but for now both NIH and NFS evaluate submitted proposals for a specific project. There are considerable agency differences regarding what is paid for, the size of the budgets, as well as who reviews, who decides and who grants the ability to resubmit.

On paper, the peer review system encourages freedom of intellectual inquiry, promotes the sharing of information, provides incentives to remain productive, and encourages entrepreneurship among US scientists. In reality, it has created numerous problems.
Firstly, it has created a strong bias towards risk aversion. Scientists submit proposals they see as “sure bets”, because approximately one third of all NIH-funded researchers are on soft money and need grants to survive, and also because there are strong incentives to continue a line of research rather than start afresh with a new one. This is a significant concern for economic growth. Incremental research yields results, but in order to realize substantial gains, some people need to do risky research.

Secondly, this system shifted the age distribution of who receives funding for research. The doubling of NIH budget benefited established scientists and the average age for an investigator getting his first grant went from 37.2 in 1985 to 42.4 years in 2006. This is of concern: there is a link between age and productivity, and we need to invest in some new talent for the future. The former head of NIH pledged before he left office to “support new investigators at success rates comparable to those for established investigators submitting new applications”. Things begin to change, but there is criticism that this has led to funding projects of lower quality.

Peer review is also expensive. Each proposal represents $1700 in terms of opportunity costs. More and more scientists, especially senior scientists, decline invitations to review, and it can happen that a proposal is judged by somebody who doesn’t know anything about the field. To counter this, NIH streamlined the procedure: projects cannot exceed 12 pages, all get scored, you can only resubmit once and if you have three or more grants, you have to serve as a reviewer.

I am also very concerned about the way the US staffs its labs. The people actually doing the research are the creative, flexible, temporary, cheap, and disenchanted graduate students and post-docs, who have more and more trouble finding a job, particularly in the biomedical sciences, but also in industry. Every five years, the NIH is required to have an outside committee evaluate how its training programs are working. Almost all the committee members are established researchers who have a huge commitment to maintaining the status quo. The last report asserted that the system has been “incredibly successful in pushing the boundaries of scientific discovery”, which I would argue is rather doubtful. Concerning the poor job outcomes, its recommendation was: “If they can’t find a job, let them be high-school teachers!”… After 12 years of training?

Because NIH supports salary with no time limit, universities are encouraged to hire their researchers on soft money positions. Some medical schools even award tenure without a salary guarantee.

The salary structure is also evolving in a way that threatens the very fabric of the university. The US built its strong research universities by having the resources to attract and reward highly productive scientists. Private universities have the resources to pay significantly more. If you list the Top20 institutions in terms of the salary they offer, the only public institution is UCLA, in 20th position. There are big differences across and within institutions, depending upon when you were hired rather than upon productivity. Though inequality may encourage people to be productive, there is now a concern that very strong public universities could lose the human resources that made them great. If the only thing that is rewarded is research productivity, it becomes increasingly hard to get a faculty to work together, despite the fact that countries and funding systems seem to want researchers to collaborate more.

Another question concerns how the U.S. is spending its resources. The biomedical sciences get close to 67% of all federal funding in the US. The reason for this very heavy focus is the existence of a well-organized disease-focused health and research lobby, which gets the attention of both the NIH and the Congress.

The rise of federal funding in the biomedical sciences led to a building boom at universities. Thanks to NIH funds, universities could hire people on soft money, but to attract them, they needed better labs, so they borrowed to construct new buildings. Now that the NIH budget is flat, universities may have trouble paying the interest on these bonds or servicing the bonds. If the funds cannot be gotten from NIH, they will have to come from elsewhere or the universities will default. By way of example, students could pay through increased tuition or faculty could pay by getting lower salary increases or even decreases.

It may be time for the United States to rethink what they are investing in. Biomedical research has clearly had a great run. It has created a lot of very strong breakthroughs, but returns are diminishing and failures rising. The basic research behind it has been lacking, in part because of perverse incentives. Many medical advances have not been developed directly in the biomedical field; many came from physical sciences, but in the US, funds for this field are at an all-time 35% low. Any country thinking of emulating the US system should be aware of what funds are allowed for. The “innovation” of soft-money positions and the response of universities have caused the U.S. serious problems. I don’t think more money is always the answer. The doubling of the NIH budget really didn’t have all the good outcomes that people had predicted.