

# THE NUMBERS GAME AND GRADUATE EDUCATION

Transcript of Remarks by Richard C. Atkinson  
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The National Science Board report Science and Engineering Indicators, 1996<sup>1</sup> has a new section this year, entitled "Science and Engineering Labor Market." It begins with the following statement: "The performance of the U.S. economy is the major determinant of current and future demand for scientists and engineers." I would argue that this statement represents a short-term perspective on the science and engineering labor market. Clearly, the current economy determines the flow of taxes, company revenues, and the number of individuals who will be hired at any given time. A long-term perspective, however, would focus on the importance of science and engineering as a driver of the future economy; the investments made in R & D today will be a dominating factor in the level of economic growth experienced in the future.

For 50 years we have had a good understanding of the role of education as a driver of the economy, but only in the past 10 to 15 years have we begun to understand the impact of R & D on economic growth. When I was the Director of the National Science Foundation in the late 1970's, we had ample anecdotal evidence about the relationship between innovations like the transistor and this or that economic variable, but very few solid economic studies. We initiated a special program at NSF in economics focused on just that issue -- the relationship between investments in R & D and economic growth. A substantial literature has evolved in the interim, which in turn has led to a development in economics called "new growth theory." This work was nicely summarized in a recent report of the Council of Economic Advisers:<sup>2</sup> 50% of the growth in the American economy in the last 40 years has been due to investments in research and development. Obviously, the private sector is a major driver of that R & D, but federally funded research of universities also plays a key role. The report points out that when investments in university research increase, there is -- with an appropriate lag -- a corresponding increase in private-sector investments. There is a well researched link between university-based research and industries' R & D efforts.

Investments in education and investments in R & D are overriding factors in economic growth. The nation faces tremendous problems -- deteriorating inner cities, homelessness, degradation of the environment, the prospect of a huge number of baby-boomers retiring with a far smaller workforce to support them in their retirement. How are we going to deal with these problems? There is only one way -- we must have substantial economic growth in this country. That means we're going to have to invest heavily in education and in R & D.

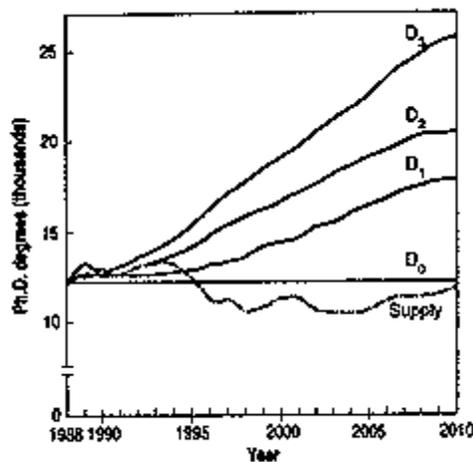
During the course of the day you'll hear about several new initiatives by the University of California. One of these initiatives is our Industry-University Cooperative Research Program. The purpose of the program is to create jobs and protect California's high-tech leadership by forging research partnerships between UC and industry. I'm very excited about the program and can report that it already is having an impact. The program will be given extra impetus by the R&D tax credit established through bipartisan legislation this year. The legislation doubles from 12% to 24% the state tax credit California industry will receive for the support of research at

universities. These are both important investments in California's future productivity and thus the state's ability to thrive in the next century.

Now I want to move to a different topic. In your packet you have an article on the supply and demand for scientists and engineers that I published in *Science* in 1990, based on work done in 1988.<sup>3</sup> This article reported on an NSF study that I was involved in, much like the study that Bill Bowen and a colleague at Princeton were doing at about the same time.<sup>4</sup> Bill and I were both projecting a significant future shortfall of Ph.D.'s. Bowen was looking at the humanities and the social sciences as well as the natural sciences and engineering. My paper was concerned only with the natural sciences and engineering, and excluded the social sciences. The study began with the year 1988 and projected the supply of Ph.D.'s that would be trained in future years. That projection was made on the assumption that a certain percent of undergraduate students would go on for Ph.D.'s, and thus was based on the demographics of the 22-year-old population. If you look back over the past 20 years, the proportion of 22-year-olds who eventually earned a Ph.D. in science and engineering is remarkably stable.

Added to that was the assumption that the number of foreign students taking Ph.D.'s in the United States in future years would remain at the 1988 level. In 1988 we had a large number of foreign students taking Ph.D.'s, and the assumption was that this number wouldn't increase significantly. A further assumption was that 50% of the foreign students who earned Ph.D.'s in the United States would stay in the United States. And these assumptions led to the wiggly curve on the chart labeled "Supply of Ph.D.'s." You can see on the far left the actual number of Ph.D.'s produced in 1988. Supply was projected through the year 2010.

### SUPPLY OF Ph.D.s



Supply and demand projected to the year 2010 for Ph.D.'s in the natural sciences and engineering. Four different demand scenarios are indicated by the  $D_0$ ,  $D_1$ ,  $D_2$ , and  $D_3$  curves.

The  $D_0$  curve was based on the assumption that the future demand for Ph.D.'s would remain constant. That is, whatever the demand was in 1988, that demand would stay the same out to the year 2010. Note that for the  $D_0$  demand curve, it is not until the late 1990's that an undersupply of Ph.D.'s begins to occur.

But the constant  $D_0$  scenario seemed highly unlikely for at least three reasons. First, yearly replacements due to retirements and deaths were expected to increase over the next two decades. Second, we considered it almost certain that college and university enrollments would increase in the late 1990s with the expanding college-age population, necessitating an increase in the number of faculty hired. Third, we assumed that if federal and private investments in R & D continued to grow at even moderate rates, the number of new Ph.D.'s required by industry would be well above the 1988 level. These three factors generate three cumulative demand scenarios labeled  $D_0$ ,  $D_1$ ,  $D_2$ , and  $D_3$ .

We knew the demographics of the workforce in 1988 and the age distribution of Ph.D.'s in that workforce, and therefore it was fairly easy to predict the expected increase in the number of retirements. If one assumed that for every Ph.D. who retired, a replacement would enter the workforce, the result is the  $D_1$  curve. If you compare the  $D_1$  curve with the supply curve, somewhere after the year 2000 you begin to see a significant divergence; an increase in Ph.D. production would have to occur in order to have an adequate supply.

Another factor was the number of undergraduates enrolled in universities. We could predict with assurance that there would be a significant increase in the number of college-age students by the late 90's. If one assumed that the ratio of faculty to students would be maintained at the 1988 level, then one would add to the  $D_1$  curve and predict a demand for Ph.D.'s represented by the  $D_2$  curve. Finally, assuming there would be growth in the number of Ph.D.'s required in the non-academic workforce, it seemed sensible to add a growth factor of 4% which cumulated to the  $D_3$  curve. After all, the private sector workforce was expected to expand, and one would expect a correlated increase in the need for Ph.D.'s.<sup>5</sup> These four demand curves represented projections based on a well-defined set of assumptions. And depending on which curve you believed, you could get quite exercised about the projected shortfall. Once I published the 1990 paper, and once Bill Bowen published his work, considerable unhappiness ensued in the academic world as the job market began to deteriorate. The fact is, however, that both sets of projections did not identify significant shortfalls in the supply of Ph.D.'s until the late 90's.

What has happened since the publication of the 1990 Science paper? One unanticipated factor was the end of the Cold War, with the resulting cutbacks in defense spending. Another factor was that the number of foreign students taking Ph.D.'s in the United States did not remain constant, as we assumed, but instead has grown at a significant rate. And in 1988 I thought a greater proportion of foreign students would choose to return to their country of origin than had been the case in the past, because those countries were becoming more competitive and more attractive for young Ph.D.'s. It turns out that the proportion that remained in the United States did not decline but rather increased.

What else has changed? Colleges and universities across the nation haven't yet experienced the kind of increase in enrollments that will be coming. Further, the student-faculty ratio has not remained constant, but rather has deteriorated. For example, at the University of California, it has changed from a ratio of about 14:1 up to almost 19:1. I hope the student-faculty ratio will return to more favorable levels in the future, but for the moment it is a clear indicator that the nation is investing fewer resources in educating college students.

Another factor was the Immigration Act of 1990. This act specified categories of individuals seeking to immigrate who had particular skills and gave them added consideration. As a result of this legislation, a large number of foreign-trained Ph.D.'s have entered the U.S. labor force. Twenty-three percent of the Ph.D.'s employed in the United States today were born in another country.<sup>6</sup> We now have the highest percent in history of foreign-born Ph.D.'s in the United States workforce.

So the question is: Is there an oversupply of Ph.D.'s? Several weeks ago I read in the *New York Times Magazine* an article<sup>7</sup> by a professor of history about the serious employment problems facing Ph.D.'s, particularly in the humanities, where the placement rate for new Ph.D.'s in history and English, for example, is less than 50%. It was a wrenching article. Without question there are disturbing problems in the humanities. Are there problems in science and engineering That depends on whom you talk to. In physics, there is no doubt that we have a problem. But consider a field like engineering. If you're a Ph.D. electrical engineer or a computer scientist, there is an oversupply of jobs. In mechanical engineering, on the other hand, there is a shortage of jobs.

In recent years the Science Indicators Report has included a new measure designated "involuntary/outside of field," meaning Ph.D.'s who cannot find appropriate work and have been forced to work outside of their area of expertise. The fields of geophysics, physics, and mechanical engineering are the three highest in terms of the percent of individuals who fall into the involuntary/outside of field category. The figure is 7.7% for geophysics, and about 6.5% each for astronomy, physics, and mechanical engineering. For a few other fields: biological science, 2.1%; computer science, 1.4%; and chemistry, 3.5%.

The point is that Ph.D. employment is very much a field-by-field issue. A close friend of mine took a Ph.D. in astronomy -- a first-rate degree and a first-rate talent. He now runs a software company on the peninsula. You can imagine his history: as an astronomer he did a great deal of work on instrumentation, which involved sophisticated computer programming. He tried for many years to land a regular faculty position, but eventually gave up. He then started his own software company and has done spectacularly well. Is he inappropriately matched to his Ph.D. program? Was it a mistake for the United States to invest in his training in astronomy? I think not. And Susanne Huttner's opening remarks about the biotech business reinforce this observation. The biotech business would not be thriving in California if we did not have a steady flow of Ph.D.'s from our universities.

Despite problems in a number of fields, therefore, it is disturbing to hear some people make the blanket statement that we are training too many Ph.D.'s. Certainly physicists and humanists will resonate with that notion. But to jump to the conclusion that the nation faces an across-the-board oversupply of scientists and engineers is inaccurate and misleading.

This doesn't mean we can't improve the preparation of Ph.D. students. I'm looking forward to hearing Bruce Alberts speak later today about the National Research Council study on reshaping graduate education in science and engineering. I'm enthusiastic about their recommendation to reduce time to degree. I also support the idea that the training of Ph.D.'s should be more versatile so that they have greater opportunities in the job market. And the Council's recommendation for a national employment database for science and engineering Ph.D.'s should be an immediate

priority. Such a database would be invaluable to faculty advisors and to students as they plan their future. Further, if such a database were accessible on the Internet, we would quickly realize that the information we're currently collecting is not adequate. We'd begin to expand and refine our database and have more relevant information. So I support the Council's recommendations, particularly as a way of matching more closely societal needs with the training of Ph.D's in various subfields of science and engineering.

The University of California is a major player in graduate education. We produce about 10% of the nation's Ph.D.'s. Until this year, we have had a formula-driven budgeting process for graduate enrollments that makes little sense in the current environment. To greatly simplify, from about 1960 until this year, the number of doctoral students in a given discipline was this year, the number of doctoral students in a given discipline was principally determined by the number of undergraduates in that discipline. A large number of psychology undergraduates translated into a large number of psychology graduate students. The formula wasn't quite that simpleminded -- and did take account of field-to-field differences -- but that was the basic idea. With much discussion among the faculty and little public fanfare, we've changed our budgeting process. The change takes effect this year. No longer will we tie the number of graduate students to undergraduate enrollment, field by field. We now have a budget process in which departments will not lose budgetary support if they cut back in their graduate enrollments. Until last year departments had to have large numbers of graduate students in order to receive the full set of rewards that the system had to offer. We are now changing our budgetary system so that the number of Ph.D. students in a department is driven more heavily by the job market and employment opportunities.

The topic of this symposium is biological sciences, and that of course involves medical education. In your packet you have a document titled "The University of California Commission on the Future of Medical Education." It has become clear that we must rethink the nature of medical education -how many students we educate, how many go on in different specialities, the nature of that education, and related issues. We have established a commission whose charge is described in the material you received Tom Langfitt, who is the head of the Glenmede Trust in Philadelphia, is chairman of the commission. The individual who is organizing the work of the commission is with us today -Professor Charles Wilson, a distinguished member of the faculty here at UC San Francisco. There will be a number of working papers from the commission and a final report on how we should rethink medical education in the State of California.

Let me conclude by saying that the training of Ph.D.'s to meet the nation's needs is one of the most important questions facing higher education, now and into the twenty-first century. We must be very careful about how we think about graduate education and the marketplace -- taking into account both short-term and long-term perspectives. We would do ourselves and the nation a disservice if we came to a blanket generalization that our research universities are producing too many Ph.D.'s. The problem is too complex and too important to the nation's future to yield to simple-minded solutions.

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<sup>1</sup>National Science Board, *Science and Engineering Indicators*, 1996 (U.S. Government Printing Office, Washington, D.C.).

<sup>2</sup>"Supporting Research and Development to Promote Economic Growth: The Federal Government's Role," The Council of Economic Advisers, October 1995.

<sup>3</sup>"Supply and Demand for Scientists and Engineers: A National Crisis in the Making," *Science*, Vol. 248, 27 April 1990.

<sup>4</sup>W. G. Bowen and J. A. Sosa, *Prospects for Faculty in the Arts and Sciences* (Princeton University Press, Princeton, N.J., 1989).

<sup>5</sup>To save time, I have provided a very cursory explanation of these projections. The original paper should be consulted for a more detailed account.

<sup>6</sup> National Science Board, *Science & Engineering Indicators*, 1996.

<sup>7</sup>Louis Menand, "How To Make a Ph.D. Matter," *New York Times Magazine*, September 22, 1996.