

# How and Why Government, Universities, and Industry Create Domestic Labor Shortages of Scientists and High-Tech Workers

By Eric Weinstein

(Working Draft)

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## **Introduction: Are Shortages of U.S. Technical Workers Being Deliberately Created By Government Market Interference?**

Long term labor shortages do not happen naturally in market economies.

That is not to say that they don't exist. They are created when employers or government agencies tamper

with the natural functioning of the wage mechanism.

To get an idea of expert opinion on this topic, consider the 1990 testimony of Dr. Michael S. Teitelbaum, later to become Vice-Chairman of the U.S. Commission on Immigration Reform and considered by many, the foremost expert on the migration of the highly skilled:

"...the very phrase itself, "labor shortage" provokes puzzlement or amazement among most informed analysts of U.S. labor markets. "

"[To attract] workers, the employer may have to increase his wage offer. ... So when you hear an employer saying he needs immigrants to fill a "labor shortage", remember what you are hearing: a cry for a labor subsidy to allow the employer to avoid the normal functioning of the labor market."

*-1990 Congressional Testimony of Dr. Michael S. Teitelbaum*

The U.S. provides employers with access to the world's most productive workforce of more than 100 million individuals; an excess of talent and manpower far beyond the needs of any employer or field. In the absence of interference with the natural wage mechanism, salary offers rise to the level which gives an employer, access to the share of labor he or she needs. Organizations which lack the ability or will to compete in this dynamic market are replaced by healthier or more generous employers.

In 1998 we are again hearing that America's colleges and universities are neither attracting nor producing enough U.S. knowledge workers in the form of scientists, engineers, programmers and information workers to meet the needs of business and universities. In the case of programmers and information workers, the claim is that this is far more serious than a spot shortage lasting the few months needed to raise wages and train new workers. Instead, some industry advocates have termed this a long term crisis which threatens the health of the U.S. economy.

Economists tend to dismiss such analysis out of hand as the alarmism of individuals who have, for whatever reason, failed to grasp the most basic of economic principles. While the claims of ruin may safely be discarded as political theatrics, the domestic shortage claims deserve more scrutiny and need not be as far fetched as some market experts might assume. Most economists would agree that if previous 'employer relief' efforts have been left in place, a domestic labor shortage could well result.

Dr. Teitelbaum put this mainstay of market analysis in its simplest terms:

"[Proposed] provisions to rectify a 'labor shortage' have the perverse effect of assuring continuation of such 'shortages'"

*-1990 Congressional Testimony of Dr. Michael S. Teitelbaum*

Thus, if industry and universities are in fact facing a long term domestic labor shortage, the most likely explanation is that it is due to previous wage tampering in the skilled labor markets related to knowledge workers.

The natural wage rate in the U.S. economy is set by a simple right of first refusal (called labor certification). U.S. employers are free to hire any resident whether immigrant or citizen without regard to citizenship. If no qualified resident is available, they may then sponsor (at some cost to themselves) a non-resident who wishes to gain a permanent visa.

As long as this mechanism is not abused, standards of living are not lowered by depressed wages in other countries, employers invest in domestic training, and enterprising institutions make tidy profits.

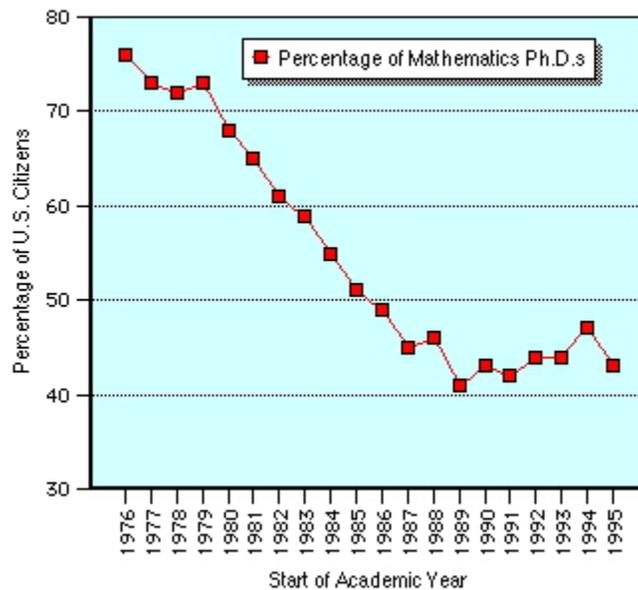
In such a market economy, employers signal a need for domestic talent through improving wages, benefits and terms of employment. They signal a desire to avoid the high prices for domestic talent by turning to government in search of visas. Domestic workers respond positively to employers who choose the first route by leaving those who opt for the latter.

As workers are expected to bear the losses when demand sags, it is generally agreed that they are entitled to reap the benefits when markets tighten. When employers use coded language like a need for 'wage stability' they are indicating to potential employees that they favor a climate where workers assume the risks from market forces, but not the full returns. It comes as a surprise to few that such employers may encounter more difficulty attracting domestic talent than employers who are unafraid to compete at the natural wage rate.

The purpose of this article is to argue that employers in government, universities, and industry, have recently lobbied (1975-1976, 1986-1990) for the purpose of avoiding and depressing the natural market price for U.S. knowledge workers. By creating a nearly identical panic to the one today, this group of employers motivated changes in immigration law and obtained government training funds to create an artificial demand for technical skills.

The effect of deteriorating terms of employment and depressed wages has had a steady cumulative effect on the relative attractiveness of advanced technical training for the best U.S. students

**U.S. Citizen Share of U.S. Mathematics Ph.D.'s**



While, according to National Science Foundation (NSF) analysts, the original concern was depressing U.S. PhD level salaries in science and engineering, the market flooding which resulted was far broader as the mechanisms (such as H1-B visas and the so-called "Einstein Exemption" from labor certification for priority workers) were quickly utilized by employers in neighboring fields (e.g. software design and securities analysis).

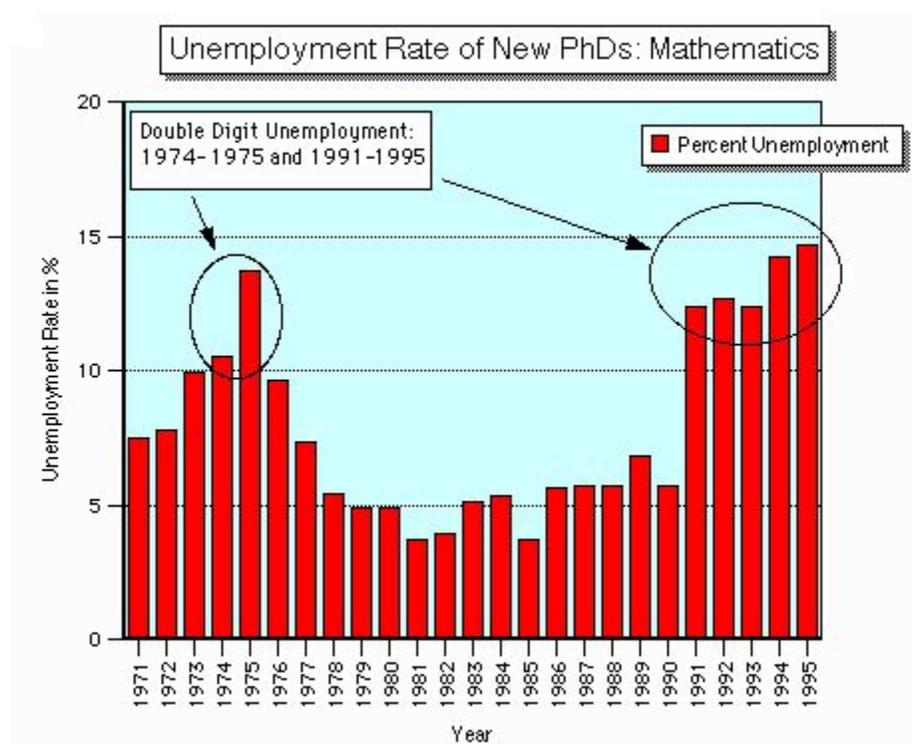
For the sake of simplicity however, this article will concentrate on the market from which this panic

spread: natural scientists and engineers (NS&Es). Those interested in other fields can easily track down how the market interventions described here relate to their fields of interest.

#### Acknowledgments:

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### The 1990s and The Flooded Market for Scientists and Engineers



Among serious analysts, who have examined the surge in Science and Engineering (S&E) PhD production, there is little question but that

1. The market has been glutted since the beginning of the 1990s.
2. The magnitude of the surge in production emanates from the temporary visa sector with smaller increases and fluctuations among immigrants and citizens.

This second observation shows up in the analysis of those who have studied the data on both the student and post-doctoral sectors:

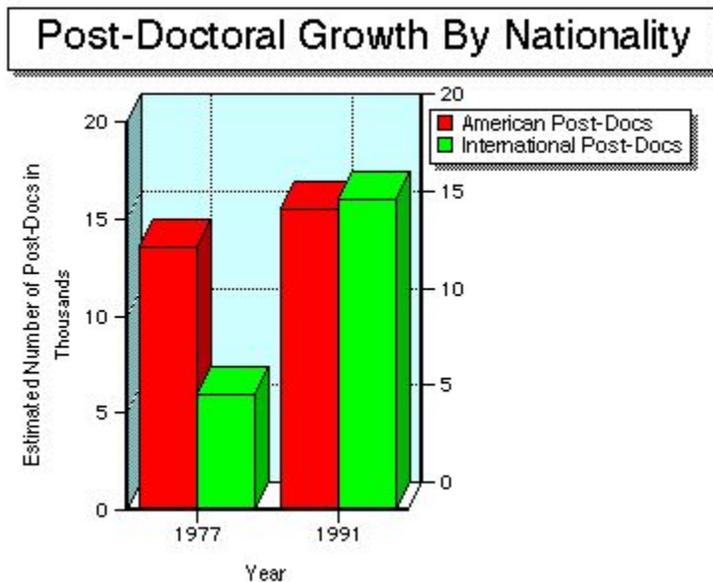
"...foreign [science and engineering] students account for nearly all of the increase in the

number of doctorates awarded in these fields since that figure began to rise in the mid 1980s. Clearly, immigration is a critical element in formulating policy for the science and engineering labor market."

*-Fechter and Teitelbaum, "A fresh approach to immigration," ISSUES IN SCIENCE AND TECHNOLOGY, Spring 1997, pp 28-32.*

"...the big growth over the last 15 years in postdoctoral education in America has been among international students. In science and engineering, the number of domestic postdoctoral students has stayed relatively constant, going from roughly 13,500 in 1977 to 15,500 in 1991. Over that same period the number of international postdoctoral students in American universities has nearly tripled, from about 6,000 to 16,000. Foreign nationals now comprise the majority of all science and engineering postdocs in the United States. Again, these numbers are probably soft, but my guess is that the fraction of postdocs in America who are international students may be even higher than these numbers indicate."

*-Steven B. Sample, President, University of Southern California, "Postdoctoral Education in America", a Speech to the AAU, September 23, 1993*



"Foreign [science and engineering] students are in fact, at the heart of both the "glut" and its beneficial effects for the United States. ... First, the facts: In 1990, over 50 percent of the engineering Ph.D. s in the United States were awarded to foreign students. The figures are almost as high in mathematics, physics, chemistry, and computer science. More than eight out of every ten foreign graduate students in the U.S. is in a S&E program, with over half of these students coming from just four countries: Taiwan, China, Korea, and India .... As increasing numbers of foreign students have arrived, native enrollments have held constant over the last 30 years at around 13,000 annually."

*-Jagdish Bhagwati and Milind Rao, "The false alarm of 'too many scientists'", Vol. 7, American Enterprise, 01-01-1996, pp 71.*

There is also agreement among these analysts on a third point: this saturation of the market is allowing

scientific employers unprecedented opportunities to save on labor costs by decreasing wages, benefits and commitments:

"By keeping wages low and by attracting a broader pool of talent, immigration produces benefits for the universities, research institutes, and corporations that employ scientists and engineers."

*-Fechter and Teitelbaum, "A fresh approach to immigration," ISSUES IN SCIENCE AND TECHNOLOGY, Spring 1997, pp 28-32.*

"There is a suspicion that international postdocs are in many cases a form of slave labor within the American research establishment. ...

There are some very touchy issues surrounding the question of international postdoctoral students. We can certainly identify some advantages to having these students on our campuses....international postdoctoral students provide a good deal of low-cost talent for our universities. They often serve as teachers in our research laboratories by supervising both doctoral and masters students."

*-Steven B. Sample, President, University of Southern California, "Postdoctoral Education in America", a Speech to the AAU, September 23, 1993*

"[The preponderance of foreign students in S&E programs] means that scientist and engineer gluts, and consequent gripes against universities, can be expected to continue.

But why should we take this as a problem? As these Ph.D.s eventually take jobs downstream, their expertise becomes available to institutions and firms that can benefit from superior talent and education at unexpectedly affordable prices. ... This should be a matter for satisfaction, not lament."

*-Jagdish Bhagwati and Milind Rao, The False Alarm of 'Too Many Scientists'.., Vol. 7, American Enterprise, 01-01-1996, pp 71.*

"There is a crisis of overproduction of PhDs and underconsumption of scholarship. To save money, schools rely increasingly on "gypsy scholars" drawn from the reserve army of unemployed PhDs. They are hired on short-term contracts to teach but are not on the tenure track and are denied health care and other benefits.

Twenty years ago, 25 percent of all faculty members were part time. Today 42 percent are. For example, the Chronicle of Higher Education reports that in 1992 the California State University at Hayward had 407 tenured or tenure-track professors and 142 other lecturers, and by 1995 the numbers were 373 and 330 respectively."

*-George F. Will, "Labor Turbulence Goes to College"*

The quotes in the [Wage Box](#) on the opposite page give further indications of how this process is viewed.

As can be inferred from the above, most analysts agree that this depression of the S&E labor market is highly advantageous for employers. However, the question of whether the effects of a flooded market are good or bad for the nation is not at all clear and is frequently contested between even the most

knowledgeable of analysts.

Even more importantly, the conclusion that the saturation stems from the temporary visa sector leaves a puzzle. Temporary visas for graduate level study are officially intended for international student exchange and are technically only available for those students who can attest that they have no intention of immigrating. Additionally, the number of permanent visas for employment based immigration of skilled workers has historically been small (27,000 per year) and is limited to occupations in which no qualified immigrants or citizens are available or interested in the positions offered. Thus, if the dramatic increases in Ph.D. growth are coming from temporary non-immigrant visa programs, why should the market for permanent positions be affected?

### **Threats of Shortage and the Immigration Act of 1990**

According to the National Academy of Sciences, the increase in production was accompanied by a surge in immigration. This increase was thought to have been the result of the Immigration Act of 1990 which ironically responded to NSF predictions of shortages of scientists and engineers:

"In 1992, [the number of immigrant scientists and engineers] jumped to nearly 23,000 compared with 11,000 - 12,000 a year during the 1980s (NSB, 1993:82). More than half were from East Asia, and two-thirds to three fourths have been engineers. The increase probably resulted from the Immigration Act of 1990, which was passed in response to predictions by NSF and others in the late 1980s that a shortage of scientists and engineers was impending."

-"Reshaping the Graduate Education of Scientists and Engineers", National Academy of Science, COSEPUP subcommittee, 1995

Michael Teitelbaum, vice-chairman of the U.S. Commission on Immigration Reform and Officer of the Sloan Foundations concurred stating:

"There is no shortage, there is a surplus.

Claims that there was a dearth [of scientists and engineers] began a decade ago, when Erich Bloch, then-Director of the National Science Foundation, claimed that unless action was taken, there would be a cumulative shortfall of 675,000 scientists and engineers over the next two decades.

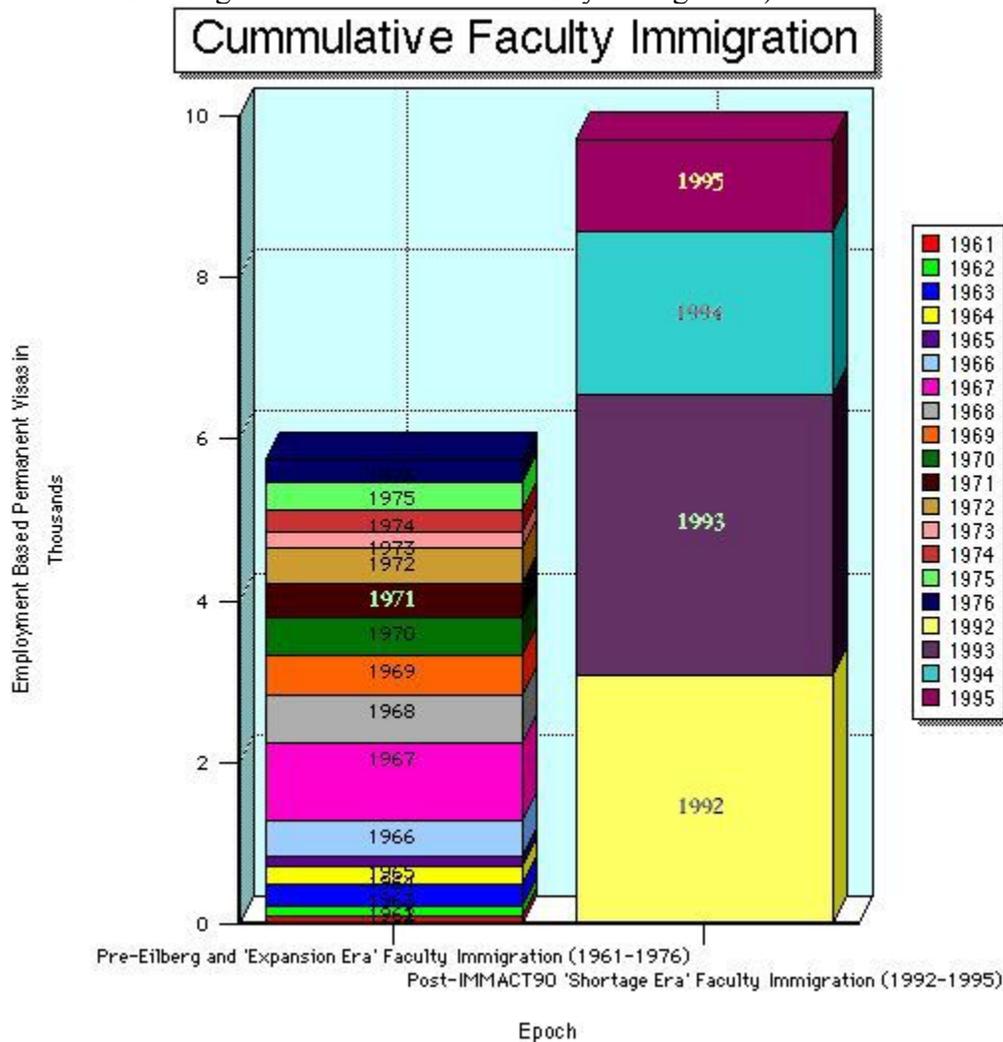
Congress poured in additional money. The National Science Foundation received tens of millions of dollars for science and engineering education. And in 1990, Congress nearly tripled the number of permanent visas for highly skilled immigrants.

Dramatic growth ensued. The number of science and engineering doctorates reached record levels."

-Michael S. Teitelbaum, "Too Many Engineers, Too Few Jobs", The New York Times, March 19, 1996

While immigration of academicians and scientists to the United States has been a traditional feature of the U.S. research community, the current levels appear to be without precedent. Consider the graph below which contrasts the in-migration of professors over the first 4 years following the 1992

implementation date of the 1990 immigration act, with the migration levels over 16 years during the 1960s (the so called era of university expansion) and 1970s (until the passage of the Eilberg Amendment which first changed the structure of university immigration).



The NSF sponsored shortage initiatives emanated from a single division within the foundation. This insular unit was known as the Policy Research and Analysis division (PRA) and, together with its controversial director Peter House, maintained an especially close relationship with the then NSF director Erich Bloch.

In the mid to late 1980s, the NSF began circulating an unorthodox demographic study projecting scarcities of more than half a million scientists and engineers:

"But panic about coming shortages soared in 1989, when Peter House, the chief of policy analysis at the National Science Foundation, circulated a paper -never published- that calculated a "shortfall" of nearly 700,000 bachelor degrees in science and engineering between 1986 and 2011. ... the shortage alarms were strongly reinforced when a widely publicized study by Richard Atkinson, then-president of the American Association for the Advancement of science, warned that a shortage of several thousand new PhDs in science and Engineering would hit the united states late in the decade"

-Daniel S. Greenberg, "A Shortage of Scientists and Engineers", Washington Post, August

18, 1991, Page C7 (Wolpe Page 583)

The projections proved so erroneous that the current NSF director, Neal Lane, has since repudiated the projections claiming that the shortage alarm was groundless:

"[The NSF scarcity study] went on to project the Ph.D. replacement needs would double between the years 1988 and 2006. Based on a number of assumptions, these data were pretty widely interpreted as predictions of a shortage, while there was really no basis to predict a shortage."

-NSF Director Neal Lane, Congressional Testimony, July 13 1995

### **The NSF Scarcity Projections vs. Standard Economic Methodology**

The unorthodox nature of the study stemmed from its exclusive focus on the supply-side of the labor market. While this 'supply side economics' or 'trickle-down theory' dominated the conservative political arena during the era of Reaganomics, the movement was regarded by academicians as 'voodoo' economics and was universally derided by even the most conservative economics researchers.

Economist Paul Krugman explained the origins of this movement in his book *Peddling Prosperity: Economic Sense and Nonsense in the age of Diminished Expectations*:

"...not only is there no major [university economics] department that is supply side in orientation; there is no economist whom one might call a supply-sider at any major department.

Where, then, did the supply-siders come from? The answer is that they came from the fringes of economics: from journalism, from congressional staff positions, from consulting firms; ... Above all, the cutting edge of the supply-side movement consisted of the group that Robert Bartley assembled to preach on the editorial page of *The Wall Street Journal*.

...Supply-siders do not fundamentally rely on empirical evidence to back their view; they believe that their ideas are necessarily, logically, right, and that the academic majority is wrong not only about parameters but about principles.

Or, to put it another way, the supply-siders are cranks."

Not surprisingly, the NSF supply-side 'scarcity' study was not viewed kindly by serious analysts. In fact, one of the great mysteries of this era was why the NSF, which had hired talented applied economists, would opt for a 'crank' methodology derided by skilled analysts. In the words of Howard Wolpe who lead the house investigation into the NSF irregularities:

"The NSF study projected a shortfall of 675,000 scientists and engineers without considering the future demand for such individuals in the marketplace. It simply observed a decline in the number of 22-year-olds and projected that this demographic trend would result in a huge shortfall. This could be termed the supply-side theory of labor market analysis. But making labor market projections without considering the demand side of the equation doesn't pass the laugh test with experts in the field."

-Howard Wolpe

Authors David Berliner and Bruce Biddle, concurred in their book "The Manufactured Crisis":

"In 1985 the National Science Foundation (NSF), no less, began an energetic campaign to sell the myth [of a shortage of scientists and engineers], basing its actions on a seriously flawed study that had been conducted by one of its own staff members. The study in question argued that supplies of scientists and engineers would shortly decline in America and that this meant we had to increase production of people with these skills. This thesis was dubious at best, but, worse, the study made no estimates of job-market demands for scientists and engineers. Thus, the researcher completely forgot to worry about whether these people were likely to find jobs."

-David Berliner and Bruce Biddle, "The Manufactured Crisis", pg. 96

## **The Supply Side Appeal**

During the period in which the NSF was advancing the shortfall hypothesis, there was tremendous political support for believing demand consideration could be de-emphasized under the hypothesis that "supply creates its own demand" (a centuries old theory, sometimes known as 'Say's Law'). Despite the opposition of serious labor analysts, conservative non-academic institutions like the Hudson Institute and the Wall Street Journal took up the charge in promoting 'shortage alleviation' in the lead up to the Immigration Act of 1990. The appeals were aggressively nationalistic and at times favored rhetoric above analysis:

"[Let us] look for people with particular criteria, particular merit, higher education. I mean, this is a buyer's market, American immigration. We can pick from tens of millions of people around the world to get the brightest best educated people --educated on somebody else's nickel, by the way-- that the world has."

*-Ben Wattenberg of the Hudson Institute, testifying in support of the Immigration Act of 1990, pg. 299*

"The U.S. has the best university system in the world, yet about half of our technical graduate school slots are filled by foreigners. As long as we don't train enough scientists, engineers or software designers ourselves, immigration is a saving grace. ... Come to think of it, with jobs available why have a quota at all? ... Our view is, borders should be open."

*-Wall Street Journal Editorial, Thursday February 1, 1990*

"As long as the teachers' unions prevent education reform, the U.S. needs to import scientists and engineers. ... Whatever happened to competitiveness?"

*-Wall Street Journal Editorial, Friday March 16, 1990*

This represented the continuation of the lobbying for the importation of large contingents of foreign laborers which had begun during the previous administration:

"Two years ago this day, ... we wrote "If Washington still wants to 'do something' about immigration, we propose a five-word constitutional amendment: There shall be open borders".... the Reagan supply-side idea has shown that human resources are the greatest national assets, if only people are freed of burdensome regulation ..."

*-Wall Street Journal Editorial, Thursday July 3, 1986*

## **The Analysts Respond**

In sharpest contrast, the traditional labor market experts called to testify during hearings on the Immigration Act of 1990 appeared unanimous that no shortage existed and warned of ulterior motives on the part of government and employers:

"Now, my first concern is the premise upon which some of these provisions rest; namely, that we have a labor shortage that cannot be corrected by normal market forces. This is just not true. The United States has an immense and talented labor force of 125 million persons, people with a vast range and variety of skill and ability ... The idea of bringing in [immigrants] for a particular job is ludicrous. It results in people lying and government agencies being asked to certify that shortages exist without any real knowledge of it. We should not do it."

-Malcolm Lovell Jr., Director of the Institute for Labor and Management at George Washington University in testimony concerning the Immigration Act of 1990.

The quotes in the **Predictions Box** on the right hand side of the opposite page, are representative of employers's, economists' and demographers' responses to the 1990 act.

While, the economists and demographers failed to stop the immigration act in 1990, vindication came two years later when a glut appeared where shortage had been predicted. The House of Representatives held hearings which revealed the shortage study to be the product of a maverick initiative within NSF"

"In 1985, the Policy and Research Analysis Division (PRA) of the National Science Foundation began to work on a demographically based study projecting a "shortfall" of 692,000 bachelor's degrees in natural science and engineering. The study was a deceptively simple one. It held that as the participation rate of 22-year-olds in natural science and engineering degrees had been stable for decades and the number of 22-year-olds was dropping, there would be a shortfall of degrees.

In 1986, the then-director of the Foundation took that number to Congress and started the shortfall ball rolling in his FY 1987 budget testimony. In 1987 PRA furthered it by publishing and distributing to over a thousand people a "draft" of the study. It had never been peer reviewed or given any other type of serious methodological review before its release. Because of the confusing and interchangeable use of the words "shortfall," "shortage," and "scarcity," and discussions by Foundation officials of supply and demand, many members of congress, academic institutions, the media and the public became convinced fewer degrees meant that a real "shortage" of workers was looming and government intervention in the form of increased financial support for science and engineering education was necessary.

At least 10 other drafts were produced and distributed between 1988-90 with varying numbers and years of shortfall. They became known as NSF's "underground literature" with different people possessing different drafts. PRA settled on a constant number of 675,000, but, strangely enough, the years charted changed from report to report without any change in the number. This was relatively easy to do, as the report contained no statement of methodology, data points, lists of assumptions or bibliography.

From the very beginning, labor economists and statisticians, including those inside the Foundation, scoffed at the methodology as seriously flawed, pointing out that new graduates were only one part of supply -- or as one critic said, "The world is not run or determined by 22-year-olds" -- that it was not useful to look at supply without looking at demand, and that the market was very flexible in adjusting to demand. The Foundation's statistical unit found that the "stable" participation rate wasn't stable. However, the study, through its repeated use in speeches and testimony by the Foundation's director, university administrators, members of Congress, and countless articles and news stories, took on a life of its own that was slowed only when the engineering community publicly attacked it in late 1990. I am going to put a few examples of its use into the record, which include a finding of a shortage of 675,000 scientists and engineers in the Excellence in Mathematics, Science and Engineering Act of 1990 passed by this Committee. Even today, the study's echoes still are heard in news stories and halls of Capitol Hill. Senator Danforth cited it in discussing the NASA authorization bill last year; Fortune Magazine referred to it last month."

-Rep. Howard Wolpe's Opening Statement as Chairman of the Hearing Before The Subcommittee on Investigations and Oversight of the Committee on Science, Space, and Technology, U.S. House of Representatives, One Hundred Second Congress, April 8, 1992

This calls into question what the real objectives of the NSF and PRA were at the time.

In order to understand why the NSF was predicting shortages and shortfalls of scientists and engineers it is important to understand the thinking of the NSF division which promoted the scarcity hypothesis.

### **The NSF's Real Shortage Study**

By excerpting and dissecting a previously unknown NSF shortage study, I will argue here that those accusing the NSF and PRA of incompetence were inaccurate in their accusations. Further, it is asserted that the individual analysts and economists within PRA were less venal and more honest than the critics imagine. While the disturbing tone of this internal document leaves little doubt about the surrounding atmosphere in the PRA at that time, a good policy analyst or applied economist is called upon to perform his or her craft as a 'hired gun' relative to what economists call an 'objective function', which is supplied externally. If fault lies with these objectives, then it must be recognized that this is the responsibility of the project's directors and not the analysts. The analysts in turn are in turn responsible for any defects in the technical analysis relative to the stated objectives.

The argument will proceed by demonstrating that the Reagan-era NSF and PRA were far from incompetent and that the flooded market might be considered more success than failure by their standards. The PRA analysts included talented applied economists, who had analyzed in detail much of the demand side and incentive structure of the S&E labor market. In fact, the accusation by Berliner and Biddle above that the widely circulated scarcity study "made no estimates of job-market demands" does not mean the analysts "completely forgot to worry about whether these people were likely to find jobs."

What appears to have happened instead is that the researchers in the group had already performed a market study of the demand projections before the infamous scarcity study was circulated. This original study explicitly projected the salary increases which would be needed to eliminate the so-called 'shortage' and found that the natural wage level would nearly double the 1982 salary level.

As one might expect of economists working on behalf of NSF/PRA, the analysts sought to publish these intriguing results, but according to government sources, the PRA director chose instead to suppress their

publication. The study was then circulated in a controlled manner to various individuals at NSF as an 'internal PRA analysis', and to select representatives of other interested parties.

According to sources within NSF, the study may have revealed too much about the political motives of the division chief and was thus perceived to threaten the PRA's political agenda. The document shows that the PRA was studying past wage trends in order to project the future salaries of Ph.D. level researchers and clearly reveals that the prospect of rising wages as the 'pessimistic scenario' motivating the later 'shortage study':

To begin we support the above allegation by quoting directly from the market study:

#### **Future Scarcities of NS&E PhD's**

The major reason for studying the past is to monitor current and future developments that will change key relationships between new graduates and pay rates. It is almost always advantageous to know about impending future changes in advance. Policy makers can act on advance information to alter changes in advantageous ways."

In order to quantify the 'scarcity', the PRA then used past salary data to project what the natural market salary levels would be:

"These salary data show that real PhD-level pay began to rise after 1982, moving from \$52,000 to \$64,000 in 1987 (measured in 1984 dollars). One set of salary projections show that real pay will reach \$75,000 in 1996 and approach \$100,000 shortly beyond the year 2000."

Thus the PRA directly conceived of the scarcity as a wage issue as the following paragraph makes clear:

#### **"The Issue of Foreign Citizens in U.S. Doctoral Programs**

This pessimistic scenario of rising PhD scarcities and rapidly rising salaries serves to highlight some of the key issues that will be faced in the U.S. over the next several decades. First, the cost of decreasing U.S. reliance on NS&E PhD's earned by foreign citizens appears to be high. Not only will the salary costs of PhD-level researchers and teachers rise substantially, but also the scarce talent lured into the PhD-level NS&E career paths will not be available for other uses."

This indicates that despite external calls for more talented Americans to enter scientific careers, internally members of NSF were actually worried about the wisdom of 'luring' talented U.S. students into the scientific labor market.

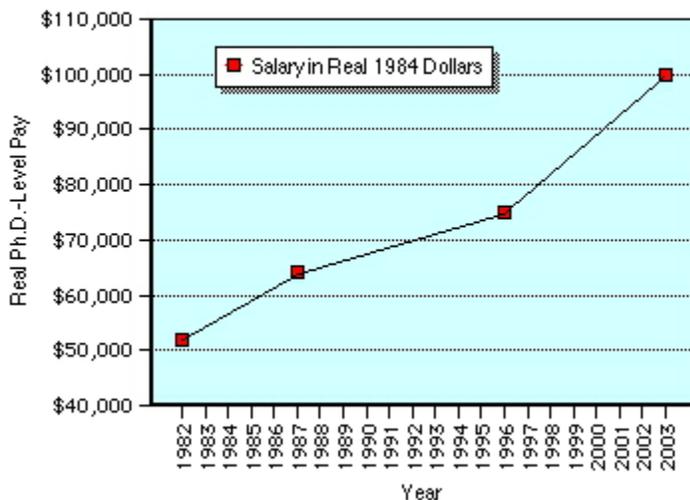
This lead directly to the idea of encouraging foreign scientists with fellowships and green cards for their effects on wages and costs:

"[Thus, to] the extent that increases in foreign student enrollments in doctoral programs decline or turn negative for reasons other than state or national policies it may be in the national interest to actively encourage foreign students. One way to do this is to ensure that foreign students have equal access to graduate student support funds provided through federal agencies. Another approach is to grant permanent resident status or immigrant status to foreign students successfully completing PhD degrees at U.S. institutions."

The effect of such a program was clear to the analysts at PRA:

"A growing influx of foreign PhD's into U.S. labor markets will hold down the level of PhD salaries to the extent that foreign students are attracted to U.S. doctoral programs as a way of immigrating to the U.S.. A related point is that for this group the PhD salary premium is much higher [than it is for Americans], because it is based on BS-level pay in students' home nations versus PhD-level pay in the U.S. . "

### NSF/PRA 'Pessimistic Scenario': Doctoral Wage Projection



Further, according to PRA analysis, while Ph.D.s bundled with immigration opportunities represent large bonuses to talented foreign students, the PhD (bundled with immigration depressed salaries) actually represent a losing proposition for many of the best U.S. scholars:

"[If] doctoral studies are failing to appeal to a large (or growing) percentage of the best citizen baccalaureates, then a key issue is pay. The relatively modest salary premium for acquiring an NS&E PhD may be too low to attract a number of able potential graduate students. A number of these will select alternative career paths outside of NS&E, by choosing to acquire a "professional" degree in business or law, or by switching into management as rapidly as possible after gaining employment in private industry. For these baccalaureates, the effective premium for acquiring a PhD may actually be negative. Serious attention should be given to this interpretation."

The reason for this loss is that the true cost of even a fully subsidized Ph.D. is determined by the indirect 'opportunity cost' of all wages forgone during periods of study and training which may last a decade or longer. Given that the PRA had previously concluded that the Ph.D. had 'negative' value for many of the most talented American students, the division had to consider that students would have to be 'lured' into Science and Engineering graduate programs. While this surely seems unnecessary and antithetical to the principle underlying a market economy, the division was interested in intentionally disallowing the action of the 'free market' which would cause wages to rise. For this reason, PRA's analysis advocated that 'lures' be used to attract citizens into science and engineering careers with the possibility of 'falling real salaries'.

From this perspective, the best 'lure' was taken to be the quickest and cheapest: graduate fellowships and traineeships.

"Considering that a key part of the financial calculus of deciding on graduate school or employment after earning a BS degree is the opportunity cost of lost earnings and the immediate out-of-pocket costs of tuition and living expenses, increased financial subsidy of doctoral students seems much more cost effective to the nation than the free market solution of allowing real and relative salaries of NS&E PhD's to rise. Subsidies are an immediate lure to enter graduate studies. By comparison, the inducement of rising salary is a distant lure, which would produce results with a considerable time lag and would probably require the payment of a large risk premium to compensate students for the possibility of falling real salaries before they have completed their degrees."

Further, despite the frequent claims that U.S. students had become disinterested in science and engineering, the PRA was aware that the phenomena of disappearing Americans could be explained without assuming any change in the native population's interest or ability. When top U.S. students are viewed as ill served by PhD training, many explanations can be given which explain the displacement including the use of immigrant visas as a kind of cash substitute.

"...these same data can be interpreted to indicate that foreign students are displacing U.S. students because foreign students are not responsive to small decreases in real starting salaries for PhD's and much more responsive to modest increases in real salaries (or that they are more responsive to the immigration opportunities represented by openings in graduate school than to salary signals)."

Given the contrast between immigration seeking scholars from the developing world and American students sacrificing first-world opportunity costs, PRA was concerned with any possible fall off which would force universities to replace foreign scholars with Americans causing both real and relative PhD level salaries to rise:

"What will occur if foreign student enrollments begin to lose responsiveness to positive salary signals, or if the growth in these enrollments begins to slow down for other reasons (e.g. if state governments begin to cap graduate enrollments of foreign students, as California has done)? In that case increases in doctoral enrollments and new PhD's will become much more dependent on U.S. citizens. In exploring the future, it is useful to consider the effect of a leveling off of PhD conferrals to foreign citizens. We examined the scenario in which foreign PhD's in NS&E reach a ceiling of 5,000 per year, a few years hence, so that the very large increases in enrollment and degrees needed after the mid 1990's would have to come from U.S. students. In addition to the rise in real salaries needed to keep pace with BS-level salaries, relative PhD-level pay would also have to rise starting in the mid-1990s to product the desired response. ..."

It did not escape PRA's attention that the effect of using foreign students to depress U.S. wages creates a feedback loop by creating more slots for international scholars.

"To the extent that the issue is inadequate pay (as just described), a continuation of current trends may actually exacerbate these trends. To the extent that the best U.S. citizen baccalaureates are choosing to avoid doctoral studies, more room will be available for qualified foreign students."

Ironically, this is just the point made in the introduction above by Michael Teitelbaum in his doomed attempt to inform the shortage alleviation provisions of the Immigration act of 1990. Unfortunately, it appears the NSF was at that time obscuring (rather than sharing) its considerable market expertise.

Despite the claims of critics, the PRA market experts were also keenly aware of the ability of markets to cope with supply problems. The internal analysis pointed out that previous shortage predictions by prominent scientists were rapidly solved by market mechanisms:

"...There have been numerous instances during the last 45 years in which high-ranking national figures have called for national action to increase the flow of college students into NS&E fields, either directly or indirectly. These calls for action were often in reaction to temporary shortages of specialists narrowly located within the broad domain of NS&E. The shortages, however, were swiftly eradicated without major focused policy initiatives through market forces and minor adjustments by employers..."

-Internal NSF/PRA study

The PRA analysts recognized that the 'shortage' was intrinsically an economic crisis as seen from the point of view of the large government, university and industry employers. As all employers were going to be experiencing the same pressure, wages would have to rise more quickly than in other sectors to draw talent from other fields. While allowing the tightening of the labor market would have brought women and underrepresented minorities to science and engineering, this tightening threatened to increase wages and decrease the spread between entry level and senior positions (referred to here as "pay compression"):

"Despite this historical tendency towards alarmism, current concerns rest on firmer ground.

...

Barring major improvements in organizational effectiveness or support equipment for NS&Es, shortages of the "classic" economic type will develop in the late 1990's and beyond. Fungibility of human talent will prove much less effective in buffering short term dislocations than it has in the past because the supply of skilled entry level people will be shrinking across the board. In addition, large organizations will find themselves coping with internal stress brought on by pay compression. The result will be renewed efforts to bring higher percentages of minorities and women into NS&E fields, relaxed attitudes towards immigration of skilled foreign nationals, greater subsidies of higher education (per student), and higher real salaries for skilled workers at all levels. The roots of these forecasts are already in evidence for workers of young ages; wage rates for "fast" food establishments have risen substantially above the minimum wage level in most large SMSA's in the Washington D.C. - Boston urban corridor, the region with the largest decline in young people. "

-Internal NSF/PRA analysis

If higher wages, xenophilia, greater investment in education and increased recruitment of women, blacks and Hispanics sounds like a progressive wish list, it should be remembered that employers were less enthusiastic as they were the ones slated to pay the price.

"A tight labor market, when unemployment is low, may be awkward for some employers, but it does wonders for workers, particularly disadvantaged ones. In a tight labor market, as in World War II, women got good blue collar jobs in factories; in tight labor markets the old and the young are courted, racial prejudices forgotten, and employers make efforts to improve wages and working conditions.

We should be extremely hesitant about using immigrant visas to loosen labor markets. As we all learned in college economics, when a supply increases, its value decreases."

*-David North, Director of the Center for Labor and Migration Studies in testimony concerning the Immigration Act of 1990.*

"...a tight labor market is the best friend of the underclass. I guess that's the way that I feel, that we should worship a tight labor market for the underclass because it really requires employers to reach down and train and retrain people and give them the jobs that they have."

*-Governor Richard Lamm in testimony concerning the Immigration Act of 1990.*

"I believe strongly that labor shortages are wonderful, and we should never do anything to eliminate that pressure, because it is forcing us to ask all the right questions about education and health, antidiscrimination policy, all the right policies are in place. In many ways, the whole idea of trying to get our nation to full employment was exactly to get itself in a state of perpetual concern about the readiness of our labor force. That is what tight labor markets mean."

*-Vernon Briggs in testimony concerning the Immigration Act of 1990. (pg. 289)*

It is not surprising however that otherwise heterogeneous employers saw the tight labor market as something of a common threat.

### **The Three Traditional Policy-Level 'Stakeholders': Government, Universities, and Industry**

According to the president of the Association of American Universities Robert Rosenzweig and his co-author John Vaughn (also of AAU), the approach of a tight labor market threatened to pit employers in government, academe and industry against each other in competition for scientists and engineers. Rather than seeing this as the normal process of wage determination, the AAU found the prospect alarming and began their 1990 article 'Heading Off a Ph.D. Shortage' with the following sentence:

"Unless prompt action is taken, a sharply increased demand for Ph.D.s in the United States will outstrip a comparatively level supply before the turn of the century. Industry, government, and universities will be pitted against each other in a battle for this critical human resource, and the entire nation will pay the price -- diminished leadership and competitive strength"

*-AAU's John Vaughn and Robert Rosenzweig, "Heading Off a Ph.D. Shortage", Issues in Science and Technology, Winter 1990-1991, pg. 67*

In fact, it is worth following the reference to "Industry, government, and universities" because these groups were in fact not functioning as independent competitors as much as one might expect. In fact, Erich Bloch was assembling and heading an new organization called the "Government University Industry Roundtable" as a 'stakeholders' organization within the National Academy of Sciences. According to its 'Mission Statement', its purpose is

"To convene senior-most representatives from government, universities, and industry to

define and explore critical issues related to the national science and technology agenda and its global context that are of shared interest; to frame the next critical question stemming from current debate and analysis; and to incubate activities of on-going value to the stakeholders.

Despite the obvious potential for conflicts of interest among competitive employers in pursuing "activities of on-going value to the stakeholders", the group adopted an unapologetic elitism and was at best tentative about its commitment to sharing its information with the public:

"This forum will be designed to facilitate candid dialogue among participants, to foster self-implementing activities, and, where appropriate, to carry awareness of consequences to the wider public."

-Mission Statement of the Government-University-Industry Roundtable 1997

Given above quotes and the fact that Erich Bloch was heading both the GUI roundtable and the NSF, it is then important to ask whether there is any hard evidence of a connection between the PRA division of NSF and the GUI group of employer stakeholders. As high levels of secrecy make it difficult to track the movements of the PRA and GUIR groups during the period before the 1990 act, this is not trivial. However, some information is available within the public record. The AAU comment of Rosensweig and Vaughn appears to be an echo of excerpt found in a public GUIR report which, in a footnote, directly references the PRA salary projections without providing a traceable citation.

"The average compensation of an academic researcher has risen sharply in the last few years [See Footnote]. The reasons for this seem to be the result of two important factors: First, universities have to compete with industry for research personnel in several fields. Second, competition among universities for top research faculty fuels wage costs. In this regard, it should be noted that during the 1990s, wage pressures will likely continue to intensify because of the shortage of and demand for teaching Ph.D.s, particularly if an increase in student enrollments materializes. Growing demand by industry for Ph.D.s, driven by the complex technological base of the service, manufacturing, and agricultural sectors, will also fuel wage increases.

Footnote: Between 1980 and 1988, average compensation for academic research personnel (faculty and non-faculty) has increased by nearly 25 percent, accounting for inflation. Source: National Science Foundation, Division of Policy Research and Analysis."

-Report of the Government-University-Industry Research Roundtable on 'Science and Technology in the Academic Enterprise: Status, Trends, and Issues' Chaired by Erich Bloch as Director of the National Science Foundation, 1989, pgs. 1-21 and 1-29

Further, when the PRA finally published a book synthesizing and reworking some of their internal analysis for public scrutiny, Both Erich Bloch and Peter House used their forwards to refer to the GUIR as motivating much of the analysis.

"While much of the database and analysis work that PRA undertakes is in preparation of NSF policies and plans, the databases themselves as well as the analysis can have broader use. For instance, during the last year and a half the Government-University-Industry Roundtable Working Group on the Future of the University Research System has made extensive use and stimulated further development of the data and analysis than was

previously required for NSF use. That connection led to the development of the volume that in front of us today."

*-NSF Directory Erich Bloch, pg. i*

"The Capstone of [our] analyses was our contribution to a Government-University-Industry Roundtable working group on the Research University Enterprise, chaired by the NSF director. To aid this group in their deliberations, PRA provided 30-year time trends (1958-1988) of all relevant economic and personnel information related to the 3,000+ institutions of higher education, with particular emphasis on the set of 185 research universities."

*-Peter House, pg iii-iv*

Given this background, it is worth noting how university representatives viewed market mechanisms as a means of scarcity alleviation. According to Rosenzweig and Vaughn:

"Relying solely on market forces [to eliminate 'Ph.D. shortages'] creates two problems: The full effect of a market response would almost certainly occur too late [for the predicted shortage of the 'mid- to late 1990s']; and there is no reason to expect that a market adjustment alone would provide an optimal, sustainable supply. .... Furthermore, current nonacademic market forces provide strong disincentives for college graduates to pursue doctoral programs. Precisely those graduates whose talents and accomplishments qualify them for doctoral programs are the job candidates most highly sought in prevailing markets"

*-AAU's John Vaughn and Robert Rosenzweig, "Heading Off a Ph.D. Shortage", Issues in Science and Technology, Winter 1990-1991, pg. 67*

The interpretation of the above statement which would be offered by an economist is that the prevailing markets function to provide efficient use of talented Americans. If the universities care sufficiently about merit, they should be expected to transfer resources from lower priorities and offer them in the form of salaries, commitments and benefits to talented scholars.

In fact the prospect of market solution to this problem was advanced and rejected as slow and costly in the famous shortage projection published by Richard Atkinson in 1990:

"Market mechanisms will no doubt reduce projected shortfalls between supply and demand, but they will be slow in coming and expensive. ... prudence suggest, therefore, that we pursue intervention strategies to increase the future supply of Ph.D.s ..."

*-Richard Atkinson, Science Magazine, April 27, 1990, pg. 430*

Years later, Atkinson gave a speech in which he asked where his projections had gone wrong. During the course of that speech he made an intriguing reference to being connected with "an NSF study" concerned with shortages:

"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. 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. 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."

-Richard C. Atkinson, From <http://www.ucop.edu/ucophome/pres/comments/numbers.html>

What that exact connection is not known to the author, however NSF sources have volunteered to the author that Atkinson was one of the select PRA outsiders to receive a copy of the internal PRA market study.

### **Further Irregularities**

Given the voluntary self-censorship practiced within PRA, questions are raised as to whether outside oversight was suppressed.

During the 1992 congressional oversight investigation into NSF/PRA activities, it was alleged by members of congress that the study in question may not have been merely a sloppy product of the Policy Research and Analysis division (PRA) and its director Peter House, but part of a directed policy program which necessitated the suppression of opposition, even by the internal NSF statistics division (SRS) which reached contrary conclusions:

"...after PRA began doing its modeling work, our work [that of the SRS statistical subdivision] was scaled back, and PRA began to interfere in the text of the section on the science and engineering workforce in Science & Engineering Indicators and other SRS work through the review process. It was at this same time that former NSF director Erich Bloch was trying to get Congress to appropriate money to revitalize science education programs.

It worked as follows: SRS publication underwent "anonymous" review by the Scientific, Technological and International Affairs Directorate (STIA) of which both it and PRA were a part. However, this "anonymous" review was usually done by PRA. After beginning the scarcity studies, PRA and Dr. House began to force changes in Science & Engineering Indicators that weakened our conclusions, based on past history and likely projected supply/demand scenarios that the labor market would adjust to any spot shortages in personnel.

For example, in 1989 I supervised the preparation of a report entitled "National Overview of Scientific and Technical Personnel," which had a new section on the projections based on the SRS model. The report did not project any significant personnel shortages. Mysteriously, it was held up for a year in STIA's "anonymous" review process. Finally, William Stewart, then SRS director, arranged a meeting with Peter House to see what the problem was. At that meeting, Dr. House said the problem was that the report did not support the director's position that there would be serious personnel shortages in the 1990s."

-Statement of Joel L. Barries, Hearing Before The Subcommittee on Investigations and Oversight of the Committee on Science, Space, and Technology, U.S. House of Representatives, One Hundred Second Congress, April 8, 1992, pg. 404-405

Beyond the obvious ethical issues raised by the suppression of criticism, it should be noted that the shortage projections garnered a strong response based in part on the perception that the American scientific establishment was governed and restrained by the scientific method. It was simply assumed, even by many savvy members of congress, that leading scientists and engineers were honor bound not to support or engage in political deceptions regardless of the potential rewards such posturing might offer. Representative Howard Wolpe made the point to Peter House at the oversight hearing in 1992:

"Well, we're here today because of a terrible misunderstanding. I mean, that's really the bottom line. Hundreds if not thousands, of people believed that your study had something definitive to say about the scientific and engineering needs of this country. Science education, immigration policy in this country have been affected by the study and by the number that was its product."

..

"One has the sense that the goal was to create the impression of a crisis to lend urgency to the effort to double the NSF budget; nothing inherently wrong with such an activity. It happens, as some people have noted, on Capitol Hill every day. Democrats and Republicans will selectively present any set of numbers in a different way to make their case.

But the difference here is that everyone up here is well aware of how that game is played. We look at each other's numbers with a great deal of skepticism, and the media shares that skepticism sometimes to a fault.

But no one expects the NSF to play that game or to take a study that has been so severely criticized from so many quarters and to pretend as if there is nothing wrong and to go forth with that in advancing its own agenda.

The NSF is the nation's premiere scientific agency. Everyone, including I think most of the media, accept as a given that NSF's pronouncements are the result of good science, really analytic kind of work.

This was not good science, this study that you produced. It has been relentlessly criticized by labor market experts both inside and outside the NSF. If you had performed this analysis for a member of Congress privately as a private kind of action, initiative, you wouldn't be here today.

But you work for the National Science Foundation, and a different standard, I think, must apply as we deal with this question."

-Howard Wolpe to Peter House, Hearing Before The Subcommittee on Investigations and Oversight of the Committee on Science, Space, and Technology, U.S. House of Representatives, One Hundred Second Congress, April 8, 1992, pg. 556-558

## **The Forgotten Stakeholders: The Knowledge Worker and Working Scientist**

Intriguingly, by including the "senior-most representatives" of Government, University, and Industry, the GUI-roundtable believed that it had represented the views of all relevant sectors of the science and engineering enterprise.

"The sponsorship of the Roundtable by the National Academy of Sciences, the National

Academy of Engineering, and the Institute of Medicine provides a neutral setting with credibility among all elements of the research community in the three sectors. All points of view are presented in Roundtable deliberations. The Roundtable avoids becoming a proponent for the views of any one constituency."

This has left some working scientists (particularly junior scientists) questioning how the concerns of working scientists are being raised as rank and file scientists, engineers, and knowledgeworkers are given neither access to such exclusive organizations nor the ability to monitor such deliberations.

The choice of the National Academy as host institution is worth noting in that it is an unusual scientific body. Critics of the Academy's government advisory role note that the academy appears to be uncomfortable with the scientific norms which promote openness, questioning and skepticism:

The academy traditionally has kept confidential all committee records except final reports, stating that such secrecy was necessary to assure ``that the results of the NAS reports are accepted universally as apolitical, unbiased analyses of scientific issues."

-"Court: Panels Subject to Scrutiny", November 3, 1997, The Associated Press

In fact, in an appeal seeking to block the forced opening of Academy proceedings on topics from nuclear waste to immigration policy, the Academy claimed that it was vital to the national interest that the academy be accepted as being "unquestioned" and "unbiased" in its judgments on controversial issues:

``Those studies ... all relate to issues that have generated and will generate important public debates, and that could create serious political divisions," the appeal said. ``The ability of one institution of unquestioned integrity to provide politically unbiased and scientifically sophisticated analyses ... is ... a matter of national importance."

-"Court: Panels Subject to Scrutiny", November 3, 1997, The Associated Press

However, as the market for junior scientists collapsed it became clear that the families of scientists and other knowledge workers were to be asked to shoulder the burden of advantages which had shifted to other 'stakeholders' (e.g. legislative changes in retirement, labor, and immigration laws). It may be inferred from the GUIRR-mission statement, that this is in part because from the viewpoint of some senior-most scientific representatives, young scientists did not constitute a 'relevant constituency' warranting a seat at the Roundtable or other such organizations claiming to speak on behalf of either 'science', 'higher education' or 'the Nation'.

The Roundtable is foremost a process----a process for bringing together the diverse constituencies concerned with the research enterprise. The ability of the Roundtable to stimulate constructive change in the system depends on the "delicacy" and the balance with which it is able to address issues that are typically complex, intractable, emotional, and controversial. As such, it is an intensely personal enterprise, whose effectiveness has depended on the ability of the Roundtable Chairman, the Council, the working groups, and the staff to work constructively with the full range of relevant constituency groups and individuals.

This is particularly noteworthy when it is considered that a reading of legal history indicates that in addition to greater per-capita funding levels, the current group of senior scientists and engineers enjoyed far greater legal protection (e.g. labor certification) and opportunity at the beginning of their careers.

According to NSF director Neal Lane:

"When I received my PhD some 30 years ago, the situation was very different. We generally could choose among several tenure track positions upon graduation.

There was also little doubt about our job security. If our work was adequate, meaning that both the funding agencies and our students tolerated our presence, our futures fell readily into place. Moreover, the fields were not so crowded. You quickly knew everyone, the literature was manageable, and, at least in my own field, there was no shortage of important, as well as intellectually challenging research topics to choose from. None of this is true today.

We did experience periods of slow growth and no growth in the job market, notably in the late 1960's after passage of the Mansfield Amendment. But very few of us ever had to play the games of postdoc roulette or get exposed to the disease known as "adjunctivitis" that is epidemic among today's academic job seekers."

-Neal Lane as NSF Director, "Separating Science Policy from Science Fiction", a Speech on December 4, 1995

As noted by some observers, the current situation appears to breach the previous social contract between junior scientists and their employers. Teitelbaum and Fechter state:

"In the past, the parsimonious stipend levels for new Ph.D.s presented few barriers to recruitment of young people, because they reflected an implicit bargain between faculty and students. Committed students were willing to make financial sacrifices for a few years in exchange for the promise of a meaningful post-training career in research. Unfortunately, the current tight market in academic employment for science and engineering Ph.D.s means that, for significant numbers of young scientists and engineers, these implicit agreements are largely honored in the breach. We are now experiencing the costs of this failure in terms of frustrated expectations and thwarted careers, and they are substantial. Inability to honor these agreements may well discourage future generations of domestic talent from pursuing science and engineering careers at the doctorate level."

-Fechter and Teitelbaum, "A Fresh Approach to Immigration", *Issues In Science And Technology*, Spring 1997, pp 28-32.

Whether or not American science and high technology industries will continue to thrive in the current turbulent environment has yet to be determined. However, it should be noted that a few years earlier, the waste of a generation of researchers was considered catastrophic by many of the same voices calling for continuation of the current status quo. We take the last word from "A Renewed Partnership", a 1986 report from the Office of Science and Technology Policy:

"In the absence of stability and predictability, important opportunities have been lost, scarce resources have been used inefficiently and, most serious, some of the brightest young minds in each generation have been lost to science and technology."

"It is important to emphasize that the most able students in mathematics, engineering, and the natural sciences be enabled to develop their intellectual potential and creativity. We are confident that this is in the national interest; it is the most effective investment that any

nation can make in its future."

-"A Renewed Partnership", A Report of the White House Science Council Panel On The Health of U.S. Colleges And Universities, to the Office of Science and Technology Policy, Executive Office of the President, pp. 4 and 27

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NOTE: Commentary and/or corrections are welcome. This represents the author's best understanding of a complex history where data, economic analysis, motivations, and incentives play large roles. The author regrets any misimpressions or mis-statements. Due to data availability and the effort needed to create new graphics, some graphs above may not be up to date with the latest data available (or may require more explanation as to data sources). Please contact the author if you have a request or an offering to make on such subjects.