

Some Thoughts on the “Gathering Storm”, National Security, and the Global Market for Scientific Talent

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The *Rising Above the Gathering Storm* report from the committee assembled by three prestigious academies of scientists certainly makes for provocative reading. Coming, as it does, at a time when Americans feel particularly vulnerable in terms of national security, it is likely to touch a nerve with many of its readers. In this note, I would like to provide a little context for the *Gathering Storm* report from work by labor economists and by thinking of the issues from the perspective of organizational economics and business strategy. I will consider some of the costs and benefits of the *Gathering Storm* recommendations and suggest a few thoughts on which proposals might be relatively higher priority. Overall, I believe that the recommendations in the *Gathering Storm* report are in the nation’s best interests, though I am not generally convinced that we need to do a better job than we are doing to *create* scientists.

The rest of this paper will focus on three issues in assessing the relationship between production of scientists and national security. First, I will think of the American economy as a large organization (similar to a large corporation) facing a “make or buy” decision with respect to a key “factor of production” (technology and/or security) and then take it down another level in the “supply chain” to think about whether we should make or buy a key input to technology (that is, scientists.) Second, I will discuss the importance of general macroeconomic health in ensuring that the United States continues to be a relatively attractive place for leading scientists to do their work. Third, I will briefly review the historical success of predictions of labor shortages in specific occupations and how that should affect related policy.

Should We “Make” Scientists or “Buy” Them?

Think of the United States government as one large corporation trying to maximize its shareholders’ value like any other large company. The people that run corporations should, for

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the most part, be trying to maximize the discounted value of cash flow to shareholders. It works a little bit differently when we think about people running a superpower, but the goal isn't all that different. A reasonable hope is that our leaders would do something along the lines of trying to maximize the discounted present value of American economic activity. Unlike a corporation, the government should be willing to give up some level of wealth in order to distribute resources more evenly. This "fairness" idea is important and relevant, so I will return to it below. But, for now, think of the government's job as simply to maximize the size of the economy.²

Almost all corporations have to consider the potential effects of competitors on their economic fortunes and take these effects into account when they make decisions. Competitive considerations are even greater for governments making decisions, however, because of issues of national security. While American corporations are largely insulated from physical attack by outside parties, the U.S. government has to insure physical security as a first step in its policy making. National security makes the standard "make vs. buy" issues faced by corporations somewhat non-comparable to the make vs. buy decision faced by the U.S. government. Dell Computer or General Motors can buy virtually any input from a supplier if the supplier can produce the good more efficiently. But, simply put, we cannot "buy" national security. If we ever relied on a foreign entity to provide our entire army or any critical weapons system, we would face the possibility of that entity threatening much of our wealth.

Because of this, and despite the fact that the US military is hardly known as a model of efficiency, the US government runs the army and directly procures all major weapons systems. That is, we "make" key national security components such as the military and advanced weapons systems.

Dell Computer and GM have made comparable decisions and they make computers and automobiles, respectively. The strategic decisions and processes underlying their decisions are very different from those that drive US national security, but the final decision is the same – they will make the final product. However, both of these corporations buy, rather than make, some of the key inputs to these final products. Dell buys processors from Intel Corporation and Advanced Micro Devices, Inc. GM buys tires, engine systems, and parts for almost every area of cars and trucks from a large set of suppliers.

² Keep in mind that I am talking about discounted value of all future economic activity. This means that good policies would include making responsible choices about use of the environment for the sake of future generations and decisions that involve giving up short-term consumption in favor of consumption by future generations.

Historically, the United States has also used a “buy” strategy for one of its key *inputs* for national security – scientific talent. Consider, for example, the production of the atomic bomb, the hydrogen bomb, and the early space program. All of these were considered important national security programs and were backed by considerable government resources. The Manhattan Project, which developed the first atomic bombs in laboratories in Los Alamos, New Mexico, was overseen by a General (Leslie Groves) and a scientist (Robert Oppenheimer) that were born and educated in the United States. However, using the very imperfect measure of all scientists mentioned on Wikipedia’s “Manhattan Project” page as having contributed to that project, a little over half of the key scientists involved were not born in the United States.³ The two scientists that were clearly most important to the development of the US’s hydrogen bomb were Edward Teller, who was raised in Hungary and moved to the United States at the age of 27, and Stanislaw Ulam, who was raised in what is now the Ukraine and emigrated to the United States at the age of 29. After these early nuclear weapons advances, the next major science-oriented security challenge came from Sputnik 1 and the onset of the “Space Race.” The United States turned to Wehrner von Braun. He was born in what is now Poland, developed rockets for the Germans during World War II, and went on to become known as the “Father of the US Space Program”. In 1961, the first American to visit space flew in a ship designed by Max Faget, who was born in what is now Belize (though his parents were American.)⁴

These examples do not by themselves ensure that the United States can continue to rely on foreign-born scientists. But they do point out that national security is not, by definition, a function of domestic scientific talent.⁵

“It’s the Economy, Stupid”

So then, how do we ensure that the very best scientists (that is, the ones that will make breakthroughs truly critical to national security) will work in the United States? We could make

³ The Manhattan Project was, to some extent, a joint project with Great Britain and Canada. However, none of the key scientists were born in either of those two countries.

⁴ The historical facts are all based on Wikipedia’s “Manhattan Project”, “Edward Teller”, “Stanislaw Ulam”, “Wehrner von Braun”, and “Project Mercury” pages, as well as on Oberg (1995). Foreign-born scientists have also been central to major non-military technical advances centered in the United States, including the development of the integrated circuit.

⁵ One might also ask the question of whether, in the current global security climate, scientific advances are the key to national security? Perhaps border inspection and forensic science advances will be critical, but perhaps just allocating conventional forces appropriately will be even more central. In any case, I will proceed under the assumption that we *need* cutting edge technology for national security purposes.

sure we train the very best scientists and then somehow insist they do not leave the country (after all, this sort of worked for the Soviet Union for a while). Alternatively, we could make the U.S. an attractive place for scientists, whether born here or not, to work.

That is, as James Carville famously said about the 1992 Presidential campaign, “It’s the economy, stupid.” That mostly means the economy overall, but it also means the environment for scientists more specifically. The United States will be an attractive place to work if scientists expect the most “utility” from working here. Scientists, like almost everyone else, get utility from more money and consumption goods. So, a vibrant economy overall will attract scientists just like it attracts any other immigrant. But scientists also get utility from a good research environment. This includes first-class universities, other research institutions (including R&D groups at corporations), and other great scientists. Here’s where we are lucky in the United States. We already have all those things. There is a “network effect” in the location of scientists meaning that a great scientist is likely to want to work where other great scientists work because this will enable collaboration and the sharing of ideas. Scientists are a “complementary” good, meaning that the marginal value of one is increased by having others nearby. As King (2004), May (1997), and other have shown, by any measure, the United States has a large absolute advantage in the production of scientific research.⁶ Though these same articles indicate there is some sign that this absolute advantage is slipping a bit, the rate of decline appears to be slow and is only to be expected given the enormous differences. The large advantage and the network effect give the United States a great combination. Unless we do something to make the country much less attractive to scientists, the advantage is likely to be self-sustaining.

So what could we do to mess things up? One possibility is to set such strict immigration policies that high-skill workers choose to move elsewhere or stay in their home country. There is anecdotal evidence that we have moved a bit in this direction since the events of September 11, 2001. Hopefully this will not be a long-term problem.

Another risk is that American universities could get worse. This strikes me as a threat worth worrying about, but not a likely outcome. American universities have proven to be a very good investment for the students that go to them and many have large and growing endowments. Government aid is important to some areas at some schools, so a dramatic cutback in

⁶ This advantage is further self-sustaining in that America’s historical strength in science has made English the international language for communicating scientific research. Talented people have an incentive to learn English, which then makes moving to the United States to study or work that much more attractive.

government generosity would present a problem. But there seems to be widespread support for continuing to fund universities at reasonable levels. Overall, I agree with Wooldridge's (2006) prediction that, "There is every reason to think that the absolute number of people from India and China who want to study in America will rise as those countries get richer."

I believe that the real risk to America's ability to attract and retain scientists comes not from the scientific community itself, but rather from risks to the state of the overall economy. That is, American universities and research institutions are doing well and, at this point, so is the American economy. But if universities ever become an island of success in a sluggish economy, then it will be hard to attract and retain excellent scientists. That's why the parts of the *Gathering Storm* report that I believe to be most important are those parts aimed at elementary and secondary education. There has been a lot written about the lackluster student achievement in the United States, as well as the variation in the quality of schools based on neighborhoods. See, for example, Gonzales, et al (2004) and Hanushek (2002). Spending on public schools in the United States has gone up consistently (see Hanushek, 2001), despite perceptions that school budgets have been tightened.

So why does it seem we are getting less for our money? Whether we are actually getting less or not is a matter of some debate, but it is surely the case that the cost of providing education in the United States has gone up over the last several decades. That is, to provide the *same quality of education* in 2006 simply costs more than it did in, for example, 1966. This is because two of the largest parts of the cost structure of elementary and secondary education are salaries of college-educated employees and real estate.⁷ Relative to other goods, the costs of these two inputs have skyrocketed over the years. Consider salaries. In the Palo Alto Unified School District, 65% of total expenditures are salaries. This includes some people who do not have college degrees, such as bus drivers and janitors, but it does not include benefits. In the state of California, 40% of education expenditures are teacher salaries. This does not include salaries of others with advanced degrees such as principals and other administrators. So roughly half of education expenditures are on salaries for college-educated employees. Katz and Autor (1999) and Autor, Katz, and Kearney (2005) document that the average wage premium for a college education (relative to someone who leaves school upon high school graduation) has risen

⁷ The idea that labor-intensive goods will become relatively more expensive over time dates back to at least Baumol and Bowen (1966). But the key point here is that the type of skill required to staff schools has become especially expensive in recent decades.

steadily since at least 1963 while the average wage discount for women (relative to men) has declined. Given that college-educated women are a primary educational input, these changes in the wage structure have added at least 10% to the cost of elementary and secondary public education. It is much harder to assess the effect of real estate on educational costs given schools generally use public land and pay no rent. However, the implicit rent being paid for school buildings is an enormous and increasing cost (or at least opportunity cost) borne by taxpayers.

Combining these basic statistics implies that, over time, we need to be willing to increase expenditures on education as a share of the total economy just to insure the quality of education does not deteriorate. Education has gotten more costly, and if predictions of further increases in the wage premium for skilled workers pan out, it will get more costly still. Why is it worth the cost? There is a huge economics literature studying the returns to education. A reasonable consensus estimate from this work is that a typical person will increase his or her earning power by about 8% for the rest of his or her career by obtaining an additional year of education and that there are non-trivial benefits of this additional education over and above the monetary value. Thinking of this in terms of an underlying economic equilibrium (that is, assuming that, over the long run people get paid, on average, the value of their labor), it must be the case that an extra year of education increases a person's productivity and contributions to the economy by 8%. So, suppose we were to freeze expenditures on education at their current levels and the relative costs of educational inputs continue to rise. Then the quality of new high school graduates' education would deteriorate.

Suppose that high school graduates at some future date learned as much as current graduates learn in their first eleven years in school. Then the value of a high school degree would drop by the value of one year of education, or about 8%. If this happened to all American students, we could expect a long-run negative effect of up to 8% in terms of total GDP.⁸ This strikes me as the biggest potential threat to the United States' ability to attract top scientific talent from abroad. If the size of our economy dropped by 8% (or, depending on educational investments, somewhat more or less), that would make the United States a much less attractive place to pursue a scientific career. I believe a bigger threat to our ability to attract and retain

⁸ I say "up to" 8% because some of the value of education is probably due to moving up in relative skill rather than absolute skill. This part of the value of education would not be lost if everyone's skill level dropped.

scientists lies in this indirect threat to the economy than in the more direct threat of not producing those scientists ourselves.

My argument that it is education, rather than scientific education, that will drive our ability to insure a healthy supply of scientists leads me to take issue with one recommendation in the *Gathering Storm* report. While I support Recommendation C (“Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists, and engineers from within the United States and throughout the world”), I do not think that the more science-specific “implementation actions” are warranted. I see no reason to think that the market for higher education inefficiently encourages people to focus on social sciences, the humanities, or professional studies rather than the physical sciences. We need educated, literate people. Communication and logic skills are just as important as science skills. I believe the job market provides the right incentives for people to invest in whatever set of skills they find fit their financial goals and their enjoyment of work. While the very elite scientists who design weapons and instruments that ensure national security provide “public goods” that we should encourage through public policy, the vast majority of people should invest in skills that take advantage of their individual comparative advantages.

Note, by the way, that the deterioration of elementary and high schools would threaten national security directly because we need these schools to educate the people who will lead our military. Though military leaders born outside the United States are not unheard of, the case for “making” military leaders seems much stronger than the case for making scientists due to American-specific military education and the fact that, all else equal, American soldiers probably respond better to American commanders. So, from a national security point of view, we need good basic education to insure high quality military leaders.

A final consideration, when thinking about the broad economic issues, is potential problems that can arise from income inequality. Income inequality has increased fairly dramatically over the last few decades (see Katz and Autor, 1999) and this trend shows no sign of slowing down (Wooldridge, 2006). While increasing inequality is a global phenomenon, it is more exaggerated in the United States. To the extent that scientists value living in a relatively equal society or that inequality leads to social unrest in the United States, this could make attracting top talent here more difficult. However, a more likely effect is that the relatively

privileged position of top talent within the United States will make this an attractive place for top scientists and others with very specialized skills.

The Reliability of Projections of Labor Shortages

Being proactive about thinking through the skills we will need for future security challenges is an admirable idea and I applaud the Academies for bringing attention to this issue. However, I think the potential shortage of scientists, and the potential shortage of “talent” more generally, should be considered in the historical perspective of past projections of sector-specific employment trends. Freeman (2006) highlights several examples where, even over a period of just a few years, economic or other factors switched labor shortages to gluts or vice-versa. He notes that, “The wide variation in the number of workers projected in computer and mathematical sciences reflects the difficulty in foreseeing future demands in an occupation subject to volatile demand from different economic factors.”

Freeman (2006) goes on to note the error in his own scientifically-grounded 1976 projection of a surplus of college graduates. He also notes that projected labor shortages in Europe and Japan over the last ten to fifteen years have not materialized.

Perhaps the most relevant past projection is the early 1980’s predictions of a large shortfall of scientists in the United States. This encouraged too many people to pursue science PhD’s which, combined with an influx of scientists after the crumbling of the Soviet Union, has led to an oversupply of physicists, mathematicians, and PhDs in other sciences. Just as an unpredicted event such as the falling of the Berlin Wall spoiled prior predictions, there are many possible events that could doom current projections. Political turmoil in Asia involving China, major new challenges in the Middle East, or some shocking new discovery about the challenges of climate change strike me as possible (though hopefully unlikely) events that could have a major effect on either the supply or demand for scientists and other high-skill people.

Again, this does not mean that we should not plan ahead or take seriously the issue of how we can ensure we get more than our fair share of major technical advances. But the unreliability of forecasts of shortages or surpluses in specific labor markets makes me hesitant to devote too many resources to a problem that might well never develop (or that might pale in comparison to some currently unforeseen problem.)

Summary

I believe that a strong national economy is our best strategy for promoting a scientific community strong enough to insure American national security. That is, to the extent that we devise policy to address the science/security relationship, it should be focused on general economic health and making this a desirable place for scientists to study and work. I have emphasized the importance of elementary and public education, but there are other policy issues that are clearly of paramount importance. Keeping the national debt under control, for example, seems like an important and (indirectly) related goal. We also need to focus some policy attention on the health care system in the United States. Just as wage structure changes have made education more expensive, changes in the wage structure and in demographics have made health care more expensive. Unlike education, which is, in effect, rationed through the public school system, health care is neither rationed nor “priced” such that decision makers bear the cost of their health care consumption choices. Addressing this, either through some form of rationing or more efficient employment of a market-based system, would help insure the economic future and, by extension, the attractiveness of the United States to scientists. Perhaps the Academies can convene their next committee around this challenge.

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