The United States is trading the long-term health of U.S. research and education for the appearance of short-term security.

A Disturbing Mosaic

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I assume that all of you have read or heard a discussion of Tom Friedman's book (2005), *The World Is Flat*. But just in case, I'll restate Friedman's premise: the international economic playing field has become flat(ter) and is now "more level" than at any time in the past. This "flattening" is the result of information technology and a glut of inexpensive bandwidth, which has made it possible for American companies to locate call centers in India, coordinate complex supply chains and work flows that enable manufacturing in China, and do "back office" work in India (e.g., Indian radiologists now read x-rays and CAT scans from U.S. hospitals, etc.). Offshoring, outsourcing, and Lou Dobb's "Exporting of America" are all manifestations of this leveling.

Friedman argues that, despite the dangers, a flat world is a *good thing* on the whole—both economically and geopolitically. Lower costs benefit both consumers and shareholders in developed countries, he says, and a rising middle class in India and China will become consumers of their own products and ours. That same rising middle class also has a stake in frictionless international commerce—and hence in stability, peace, and the rule of law. But, Friedman says, there will certainly be problems during the transition, and whether or not global flatness is good for a particular country depends on whether that country is prepared to compete on the rough-and-tumble, level, global playing field.

I was prompted to write this paper by a few lines at the very end of Chapter 6 in which Friedman describes what a country must do to prosper in a flat world:

> *But have we [meaning the United States] really been investing in our future and preparing our children the way we need to for the race ahead? See the next Chapter. But here is a quick hint:*
>
> *The answer is no.*

I am concerned not only about our lack of preparation, but also about a host of related issues. In this paper, I will raise some of these concerns, but I don't pretend to offer solutions to them. Some of these issues are technical and some are not—in fact, some of them are political (not political-party political, but "bringing the rest of the body politic along" political). Engineers tend to shy away from such things—but the stakes are too high, in my view, for us to do that now. My goal is to provoke a conversation in the larger engineering community.

Freidman talks about a "quiet crisis." I have called it a "creeping crisis," but I think we mean the same thing. You all know the storied procedure for boiling a frog. They say that if you drop a frog into boiling water, it will jump out. But, if you put a frog in cool water and heat it very slowly, the frog won't jump out, and you'll get a boiled frog. The theory is that incremental rises in temperature are not enough of a crisis to make the frog react. I don't know if this story is true, but it fits my purpose—the slowly warming water is a creeping crisis for the frog!

Our creeping crisis is not a slow, one-dimensional change like the frog's water temperature. We are facing a number of problems—not just outsourcing/offshoring—each one like a tile in a mosaic. No problem by itself creates the sort of crisis that provokes action. But if you stand back and look at the whole collection of problems, a disturbing picture emerges—a pattern of short-term thinking and a lack of long-term investment. It's a pattern for preserving the status quo rather than reaching for the next big goal. It's a pattern that presumes that we in the United States are *entitled* to a better quality of life than others and that all we have to do is circle our wagons to defend that entitlement. It's a pattern that does not balance the dangers and opportunities in current circumstances.

In 2001, the Hart-Rudman Commission, which proposed the establishment of a Department of Homeland Security, put the matter this way:

> *… the inadequacies of our system of research and education pose a greater threat to U.S. national security over the next quarter century than any potential conventional war that we might imagine.*

That report was written before 9/11, but had it been written afterward, I am sure "conventional war" would have been expanded to include the struggle against terrorism. Yet, as a country, we seem to make decision after decision to address problems in ways that trade the *appearance* of near-term security for the reality of long-term damage to our system of research and education—and hence to our *real* security. The problems facing us can be grouped into two clusters: reactions to 9/11 and disinvestment in our future.

We are intent on preserving the status quo rather than reaching for the next big goal.

Cluster 1: Reactions to 9/11

Three of the pieces in my mosaic are reactions to 9/11, clear examples of trading the appearance of security for long-term damage. I am the first to acknowledge that 9/11 *really did* change things and that it is entirely appropriate that we rethink our "balance point" with respect to each of these issues. The nature of our adversary *has* changed. The Soviet Union was both a "rational actor" and exquisitely "research capable"; terrorist cells are neither. We wanted the Soviets to know enough about our capabilities so they wouldn't miscalculate our capabilities. In addition, there was no sense in hiding what they were perfectly capable of reproducing. Although the same disclosures today might be counterproductive, the actions described below have not improved our security.

New Visa Policies

Much has been written about the impact of new visa policies on students. Although the situation has improved somewhat in the last several months (as of this writing, the average time for processing visas for students is less than two weeks), I am still concerned because the distribution has a "long tail." Some students must still wait a year or more for visas, and some senior scholars, including a Nobel laureate, are still being subjected to lengthy, demeaning treatment. These cases, not the

shorter processing time, are being reported in the international press, and as a result, instead of the United States being seen as a welcoming "land of opportunity," it is now seen as exactly the opposite. When coupled with new, demeaning procedures for photographing and fingerprinting visitors, we are not just discouraging students, international conferences in the United States, and collaboration with our international colleagues. We are dramatically altering the image of our country in the eyes of the rest of the world.

Do these measures materially increase our security? I don't know what I don't know, of course, and classified information might indicate that they do. But with an estimated 10 million people who have entered the country illegally and an immense traffic in drugs and other illegal imports, it strains the imagination to think that a dedicated terrorist and his/her weapons will be stopped by these policies.

Export Controls

Export controls were first instituted in the United States in 1949 to keep weapons technology out of the hands of potential adversaries. But they have also been used as an economic tool against our competitors. The export of controlled technology requires an "export license" from either the U.S. Department of Commerce or State. In addition, since 1994 the disclosure of information about a controlled technology to certain foreign nationals (even in the United States) has been "deemed" to be the export of the technology itself. Thus, disclosure also requires an export license.

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Reports of the inspectors general (IGs) of the U.S. Departments of Commerce, Defense, and State have suggested that the implementation of the rules governing deemed exports be tightened further. For example, they have suggested that the exemption for basic research be altered, and possibly eliminated, and that the definition of "access" to controlled technology be broadened.

The university community is rightly concerned that a literal interpretation of the IGs' suggestions would essentially preclude foreign graduate students from participating in research and would require an impossibly complex system to enforce. Given that 55 percent of the Ph.D. students in engineering in the United States are foreign born, the effect could be catastrophic.

Again, one might ask if these policy changes would improve our security. And, again, with the same caveat, I would point out that the United States is not the only research-capable country; China and India, for example, have recognized the value of research universities to their economic development and are investing heavily in them. By putting up barriers to the exchange of information about basic research, we wall ourselves off and slow our own progress. At the same time, the information we are "protecting" is often readily available from other sources.

The current idea that foreign students in our universities represent a danger to our security must be balanced with the advantages of having them here:

- Einstein, Teller, Fermi, and many other immigrants enabled the United States to have the bomb before Germany.
- Many students from abroad stay in this country and contribute greatly to our economy.
- Foreign students who return to their home countries are often our best ambassadors.
- The United States benefits economically from open trade, and our security is reinforced by a better quality of life in developing countries.
- The quality of life in the United States has improved from sharing scientific results, enabling us to "move faster" in the development and adaptation of new technologies.
- We benefit from funding basic research on the principles of nature and from a generally educated citizenry.

Sensitive but Unclassified Information

The proliferation of information designated "sensitive but unclassified" (SBU) is a less publicized problem than visas or deemed exports, but it has become a complicating factor in academic research and a bane to the National Academies. On the one hand, we agree that the issue needed to be revisited after 9/11. Some things not covered by traditional classifications—some

biotechnology, for example—clearly would be better kept from a less research-capable adversary.

On the other hand, classifying SBU information is not backed by the precise laws, limited and specified authority to classify, mandatory declassification after a period of time, and a philosophy of "building high fences around small places" that are associated with the traditional classification of information. There are no laws, no common definitions, and no limits on who can declare information SBU. In some cases, the SBU classification appears to be used to suppress criticism. In other cases, it is being used to try to restrict the publication of legitimate research results.

There is no question that we need a serious discussion about new kinds of information that should be classified. But we are not having that discussion. The wholesale application of the SBU classification is more damaging to us than seems to be understood by those who use it.

Cluster 2: Disinvestment in the Future

A second cluster of pieces of my mosaic has to do with disinvestment in the future. Continued prosperity and security have always required that we forego some current consumption to ensure a better quality of life in the future. Aside from our notoriously poor individual savings rate, I think we are also failing to invest (save) collectively.

Demise of Corporate Research and Development

The U.S. research structure evolved after World War II as a self-reinforcing triangle of industry, academia, and government. Today, one side of that triangle—industry—is missing, and the remaining structure is much less stable. Some of the most important fundamental research in the last century was done in corporate laboratories—Bell Labs, GE Research, IBM Research, and others. Today, only vestiges of these laboratories still exist, and they have a much shorter time horizon and are heavily focused on product development.

Some would say that the demise of corporate research is the result of the short time horizon of the stock market and/or the demise of the regulated monopoly in telecommunications. Undoubtedly, both of these are important factors. But I think it also represents a failure to consider research an investment rather than an expense—in effect, saying research per se has no lasting value. As a result, instead of developing public policies that encourage corporate research, we are doing just the opposite.

Funding for Research in Physical Science and Engineering

Although support for research in the life sciences has increased enormously, funding for research in most physical sciences and engineering has declined or remained flat for several decades. This seems ironic because many of the medical devices and procedures we enjoy—endoscopic surgery, smart pacemakers, dialysis machines, imaging technologies (e.g., MRI, CAT scans, and PET scans), just to mention a few—are the results of research and development in the physical sciences and engineering.

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Coupled with, and perhaps caused by, the stagnation of funding levels, federal funding agencies have become increasingly risk averse and have focused increasingly on short-term results. The most obvious example is the Defense Research Projects Agency (DARPA), which used to be a shining example of investment in long-term, visionary research. DARPA now has a limit of three-year contracts with reviews every 12 months.

I believe that even the National Science Foundation is becoming increasingly risk averse, although this is difficult to quantify. A more concrete example is at the National Institutes of Health where a recent National Academies study revealed that the average age at which a principal investigator receives his or her *first* grant is 42—partly because of requirements for evidence of an extensive "track record" (to reduce the risk). Ironically, reducing the risk for individual research projects *increases* the risk that breakthrough, "disruptive technologies" will not be found—the kind of breakthroughs that could yield huge returns.

Higher Education as a Private Good

Historically, the United States has considered higher education a public good. That is, we agreed as a society that educated citizens benefited the country as a

whole—not just the individuals who received the education. That is why we supported universal K–12 schooling; that is why we created the land grant colleges in the 1860s; that is why a system of superior state universities was created and generously supported and why scholarships were given to needy students; and that is why we passed the GI Bill after World War II and the National Defense Education Act in the 1950s.

Today, however, state support for state universities is disappearing, tuitions are soaring to replace that support, and we offer students loans rather than scholarships. These are all indications that we, as a society, now view higher education as a private good, that is, of value only to the individual student.

A particularly disturbing aspect of this change is the impact on economically disadvantaged students. College (and specifically engineering) has been a traditional path for upward economic mobility (the author is but one example). The shift to treating higher education as a private good, and the resultant shift in cost burden, have made it much more difficult for students from disadvantaged backgrounds to follow that path. In the long run, the nation will suffer from the lack of new talent that was made possible through affordable, accessible, public higher education.

Loss of Human Capital

An educated, innovative workforce—human capital—is the most precious resource of any country and is crucial in this new, flat world. Yet the number of engineering undergraduates in the United States peaked in the mid-1980s and declined by 25 percent during the 1990s. The number has rebounded recently—but not to the 1985 level. In fact, China and India both have about five times as many engineering undergraduates, and the United States now graduates only about 7 percent of engineers worldwide. Even more troubling, the percentage of undergraduates studying engineering in the United States is the second lowest among developed countries—4 to 5 percent in the United States compared to 12 percent in most European countries and more than 40 percent in China.

Conclusion

I have mentioned just some of the "tiles" in the mosaic, but many other problems could be added to the list—such as the failure to address the energy issue and the accumulation of greenhouse gas emissions—to complete this depressing picture. But these seven tiles reveal a common characteristic—they all give the *appearance* of providing short-term gains and conceal real long-term losses.

In closing, let me circle back to the issue of our flat world and the outsourcing/offshoring of U.S. jobs, especially jobs in science and engineering, which are the backbone of U.S. innovative capacity. I don't believe that outsourcing/offshoring is a piece of the mosaic, but a protectionist reaction to it is. Of course, we must help those who lose their jobs, by providing financial assistance and retraining, for example, and it may even be appropriate to protect some jobs as a short-term tactic. But in the end, the country will be strengthened only by learning to compete in this new, flat world. Among other things, that means that we engineers must deliver value that justifies our cost, but the U.S. engineering community has yet to figure out how to do that.

Addressing just one part of the problem, however, is not enough. Unless we address the broad issue of short-term thinking, our children will live in a much less privileged country, and perhaps one substantially less comfortable on an absolute scale.

Reference

Friedman, T.L. 2005. The World Is Flat: A Brief History of the Twenty-first Century. New York: Farrar, Straus and Giroux.