

STATEMENT OF B. LINDSAY LOWELL  
Director of Policy Studies, Institute for the Study of International Migration

“Immigration and the Science & Engineering Workforce:  
Failing Pipelines, Restrictive Visas, and the ‘Best and Brightest’”

For the hearing

"STEM the Tide: Should America Try to Prevent an Exodus of Foreign Graduates of U.S.  
Universities with Advanced Science Degrees?"

Presented to the

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Subcommittee on Immigration Policy and Enforcement

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I would like to thank Chairman Gallegly and the Members of the Subcommittee for inviting me to testify here today. I have studied the global mobility of highly skilled workers for two and a half decades from the vantage of policy, demography, and labor markets. Policy changes are needed to improve America's competitive advantages, but perhaps in different directions than those under current debate.

There is little doubt that immigrants benefit the U.S. economy, especially those in the S&E workforce which is the backbone of our information age economy. I am a third generation American and was raised with my Romanian grandmother, a nurse, who pushed her son to excel. My father was a Biochemist who started a private laboratory to develop new technologies to test for disease and he held several patents. His entrepreneurial drive makes it easy for me to visualize how the immigrant experience benefits us all and it makes me aware of the uniqueness of such individuals. I was also raised in southern California and during NASA's race to space and the effects of later downscaling of the aerospace industry. There is little disagreement about on the value of attracting S&E immigrants, but we should make a distinction between the supply and demand-side.

I believe that demand side policies will, in the long run, be more successful in building the American economy, and benefitting domestic workers, than finding ways to expand the immigration of S&E students and workers. I come to this conclusion, not only because it accords with my experience and logic, but because data supports that belief. Despite commonly held views about the declining abilities of ever fewer S&E students, I think the data shows that the S&E pipeline is far from broken. Despite the common assertion that there is a shortage of S&E workers, I think the data indicates a loose labor market with a ready labor supply. And despite the belief that more is better, or that streamlining visa processing is the best response to our cumbersome system, I think the challenge to constructing a competitive immigration policy is creating incentive-driven regulations to admit the best and brightest.

## **THE DOMESTIC STUDENT PIPELINE ISN'T BROKEN**

The well-known "Rising Storm" reports from the National Academies investigate America's future competitiveness, raising a number of concerns, and offering several recommendations. They and others question the strength of the domestic S&E pipeline. By domestic I mean the native born and the already resident foreign born, both adults and those who arrive as children. By pipeline, I refer to the long pathway up through high school, to college, and ultimately along the S&E career path.

My colleague Hal Salzman and I decided to look into the strength of the S&E pipeline. We were somewhat surprised to find many concerns misplaced or wrong. We explore broad "core" S&E

occupations—the natural sciences, engineering and information technology—because they share aptitudes and skills. Here the issue is whether there is a problem that calls for demand side and government interventions. While there are specific fields in which we observe hiring (demand) outpacing supply, this tends to be short-lived as supply is surprisingly responsive: take the case of petro engineers where the number of *domestic* graduates more than doubled in a few years in response to increased salaries. Our research finds that the S&E pipeline is reasonably strong even if it can and likely should be improved. Professor Salzman presented our findings to the House Subcommittee on Technology and Innovation in 2007 and I update them here.

***Large student body, small S&E workforce:*** There pool of students with the ability to pursue an S&E career is far larger than the S&E workforce. The S&E workforce is fairly small at roughly 5 percent of the U.S. labor force. The *number* of students who score high on math or science is large, and we graduate more S&E students than annual S&E workforce growth. The Bureau of Labor Statistics projects 190,000 annual S&E job openings due to growth *and* replacement needs between 2008 and 2018. Annually, between 1995 and 2007 there was an increasing number of *domestic* S&E graduates, averaging 408,000 bachelors; 78,000 master; and 21,000 doctoral graduates for a total of 507,000. The rate of growth of domestic graduates will lessen as our population ages, but there will be no sharp decline.

***International tests averages can mislead about U.S. performance:*** It is true that U.S. students regularly place mid-way in the international pack on math, albeit they perform better on science and reading. Yet, the age groups sampled internationally are not fully comparable and the ranking between countries is often not statistically significant. And as a separate sample in Massachusetts of the Trends in International Mathematics and Science Study (TIMSS) recently demonstrated, students in *individual* U.S. states test better than those in many of the smaller nations that rank above the *average* American. Furthermore, we are a large nation and we have a lot of students in the upper tail of test score performance.

***National tests show improved math scores:*** The SAT math scores of college bound high school seniors have increased steadily since 1980 after a marked dip in the 1970s. To be sure SAT math scores have recently stabilized at a level a little lower than their 2005 peak, but that is not yet a trend and may simply reflect an increase in the proportion of high school test takers. What is a trend are the smart improvements over the past two decades in the NAEP math scores of 8<sup>th</sup> graders and the steady trend upward of 12<sup>th</sup> grade NAEP math scores for all groups.

***Student interest in S&E has been steady for four decades:*** Surveys of incoming college freshman by the Higher Education Research Institute (HERI) since the early 1970s have found about one third express an interest in pursuing a S&E field of study. Additionally, Professor Salzman and I analyzed three decades of longitudinal data and found pretty much steady rates through the pipeline. That is to say there has been little change in the percent of entering high

school students who graduate with an S&E bachelor or advanced degree; or the percent who go on to an S&E job. We do not find evidence that the student pipeline is at imminent risk of failure, that it is grossly deficient across the board compared with other nations, or most importantly that it produces too few domestic students for the S&E workforce. Student interest in science and engineering has remained strong and leads to a substantial supply of S&E graduates.

### **THE S&E LABOR MARKET IS NOT “TIGHT”**

Most Economists will not readily admit that anything like a shortage of labor exists. But that is not quite right; theory says that given strong demand an existing shortage will right itself with time. Richard Freeman has shown that engineering markets have oscillated as increasing wages induce an increased supply of students and, in turn, rebounding supply lowers wages and student enrollments again decline. That is, there are short term or cyclic shortages and longer-term, structural shortages. Cyclic shortages are what temporary visas might fill until the market rights itself, while permanent migration offsets longer run structural shortages. More to the point, wages settle to a level that reflects the relative balance of supply and demand. If demand outstrips supply, wages escalate to address the shortage of labor. If there is a plentiful supply of labor, wages will be lowered. There is evidence that there is a substantial supply in the S&E labor market and that it is best characterized as loose (not tight).

**Poor retention of S&E workers:** Historically, the roughly 5 million S&E workforce is one third of the roughly 16 million workers who hold at least one S&E degree. There are far more S&E trained workers than the number employed in S&E occupations. Of course, S&E graduates may find related jobs outside of narrowly defined S&E occupations. My colleagues and I have explored a broader definition of “S&E jobs.” We start with core S&E occupations but also include as related those “non-S&E” occupations in which S&E trained workers find themselves namely medical jobs, S&E management, and jobs workers report as closely related to their education. Even with this broadened definition, about one-fifth of early career S&E graduates are in jobs that do not use their training and that increases to one third by mid-career. It is important to ask why retention is poor.

**The boomlet of S&E immigrants:** The Immigration Act of 1990 boosted the admission of highly skilled migrants. That shows up clearly as the foreign born today are roughly half of PhDs and about one fifth of master degree holders less than 45 years of age, but less than one-seventh of all older workers. We need not review the boom of immigrants in S&E fields of study, or as post-docs, or in S&E occupations. The high percent of immigrants, however, does not *ipso facto* signal a shortage of natives as some assert, the high percent may have a number of causes. Consider the independent demand for students by colleges or the dynamics of a globalized market for students and workers. In the worst scenario, immigrants may discourage the pursuit of S&E careers, for which there is limited evidence but evidence just the same. What we can clearly

say is that the immigration boomlet attests that policy is not *numerically* “restrictive” and that it reinforces an impression that immigration is a significant addition to available labor

***S&E wages lag “alternative” professional jobs:*** Some observers argue that S&E pays less, or that the wages increase slower, than “other” jobs. If S&E pays less, it suggests that other highly-skilled professionals are in greater demand and/or other factors such as a ready supply of labor are depressing S&E wages. Yet; the Department of Commerce reports that S&E occupations pay better than *all other* jobs, but that is not a comparison with jobs that compete with the S&E pipeline. Even so, *on average* S&E jobs pay more than the *average* paid to all other *professionals* in non-S&E jobs. What then is the right type of wage comparison?

Like a good researcher, I believe we need more studies; here is some of what we do know. Thomas Espenshade finds that the earnings of S&E occupations increased rapidly from 1970 to 1990 only to see wage growth fall sharply in the 1990s, which he speculates may be related to increasing immigration. Thomas Lemieux finds that core STEM occupations experienced slower wage growth than other professional jobs through the early 2000s, especially those of lawyers and medical practitioners, which he speculates may be due to outsourcing. Clair Brown’s research echoes some of these speculations for computer engineering although she is cautious about predicting the future.

What specific “alternative” professional careers appeal to individuals in the S&E pipeline? In the HERI surveys, focusing on college freshman who intend to pursue S&E studies, we find these freshmen report their preferred non-S&E careers to be medical practitioner, veterinarian, teacher (secondary), business executive-manager-administrator, lab technician or hygienist, lawyer or judge, therapist, accountant, and pharmacist or architect. Using U.S. Census data I find that core S&E occupations paid better and had faster wage growth than these non-S&E alternatives after WWII through the Sputnik and cold war decades, but they increasingly paid less than these alternative jobs by 2000 and 2009. This is consistent with the impression that there is not a labor shortage in today’s S&E market, but rather it is loose.

## **THE BEST AND BRIGHTEST ARE NOT ABOUT MORE AND IT’S NOT EASY**

Of course, job supply is not a zero sum game and the supply of immigrants might boost innovation, productivity and the job prospects of domestic workers. Casually read most articles on this subject and they tell us that immigrants are more likely to be Nobel Prize winners and they start 25 percent or more of businesses in Silicon Valley or other high-tech ventures. William Kerr finds that H-1Bs boost patenting by Indian and Chinese inventors. Jennifer Hunt finds that the foreign born outperform natives on academic publishing, patents and their commercialization, wages, and in starting businesses. Others find that highly skilled immigrants are associated with favorable effects on economic growth.

These facts are sound, but they are not the entire story. We need to go beyond a handful of studies and, with additional data and research, ask what increasing the number of immigrants might achieve. In particular, let us consider the oft-cited study of immigrants and patents/citations which, as this committee knows, are a critical but not final harbinger of innovation in the marketplace. Moreover, empirical results at the margin do not readily extrapolate beyond the mean. In other words, if the measured impact of a 1 percent increase in skilled immigration increases patenting by 5 percent; it does not follow that a tenfold increase in immigration will generate 50 times the number of patents.

Most importantly, though less well understood, is the nature of “selectivity” in immigration patterns and flows. International mobility is always a story of selectivity, or the number of migrants who are actually the best and the brightest. Not all are. The OECD finds a mildly adverse impact of large numbers of immigrants on migrant selectivity. What is more, globalization by lowering the bar to mobility, and by creating new opportunities abroad, should lead to lower selectivity over time, i.e., a smaller and smaller proportion of migrants with that certain X-factor that generates innovation or entrepreneurial activity. In a competitive, globalizing world getting the immigrants with that X-factor should be what innovative admission policy is all about; not fighting yesterday’s battles over more or less immigration.

***The effects of globalization on Nobel Prize winners:*** Hunter, Oswald and Charlton examine the mobility of world-class scientists. They find, encouragingly, that the U.S. is one of the world’s top destinations. Yet, these migrants are no more productive than domestic scientists after they migrate. And over the past half century they have been a decreasing percentage of America’s Nobel Prize winners. What is more, as the immigrant proportion of Nobel Prize winners has decreased, the proportion of immigrants with an S&E PhD has increased. Simply admitting more PhDs has no effect on getting this very special X-factor. Then Nobel Prize winners are, we all should acknowledge, a very tiny number. The point, nevertheless, is that globalization works against selectivity.

***It takes time to grow an entrepreneur:*** Immigrant entrepreneurs are a long term bet. Vivek Wadhwa reports from his specialized, high tech sample that immigrant entrepreneurs had been in the country at least 13 years. David Hart reports from his sample of fast-growth firms that immigrant entrepreneurs had been in the country 26 years on average. In other words, the selectivity process for entrepreneurs operates through drive and experience. What we know of the process suggests they came by their drive after establishing themselves and not before. Some were, indeed, previously students before becoming greencard holders. But selectivity operates here as well. Consider the difficulties that Australia has had with awarding permanent residency to foreign graduates: incentives are muddled when an award of permanency is added to the core purpose of getting a degree. The United States retains two-thirds of foreign PhD graduates and

we have no solid data at all on whether or not rates of retention are changing. Students who are primarily motivated by their field of study are those most likely to excel and become entrepreneurs.

***Innovation and entrepreneurship:*** Immigrants are rightly lauded for starting high tech companies. Individual examples abound, but as impressive as they are one should acknowledge they are individual anecdotes. The problem with the “immigrant as entrepreneur” story is that it relies on both anecdote and surveys provide a surprisingly limited basis for generalization. Impressively, Anna Lee Saxenian famously reported that Chinese and Indian computer scientists and engineers ran one-quarter of Silicon Valley’s high-tech firms in 1998. Vivek Wadhwa found that at least one immigrant was a founder of one-quarter of all engineering and technology companies between 1995 and 2005 and up to half in Silicon Valley. Stuart Anderson finds that immigrants started one-quarter of venture-backed companies over the past 15 years. Yet, Hart et al. find that immigrants nationally were part of the founding team of a far smaller one-sixth of high-growth companies. Academics worry over what types of companies are included in these special-purpose samples and how comparable and representative they are.

Consider that Census data shows that no better than 5 percent of all workers in S&E occupations are self-employed, perhaps unsurprisingly, less than the percent of workers in other professional jobs. The S&E foreign-born, in turn, are less likely than S&E natives to be self-employed. On the other hand, in high technology industries nationally a little over one-sixth of the self-employed are immigrants, closer to Hart et al.’s figures. Again more impressively, close to three-tenths of the self-employed in IT industries are immigrants in Silicon Valley. Impressive, yes, but the valley’s share of immigrants in the S&E workforce is roughly twice as large. In other words, one has to admit a rather large number of immigrants to generate what is evidently a very concentrated pattern of immigrant entrepreneurship in key metropolitan areas.

Furthermore, it is not clear that it is immigration that provides the most critical ingredients for innovation “hot spots.” In *The Silicon Valley Edge*, Lee and his colleagues argue that there are 10 reinforcing factors behind the valley’s success, of which immigrants are only one part. Success in innovation, in the final analysis, is about creating the right business, intellectual, regulatory and academic environments; not about supply-side economics.

## **SUMMARY**

A generous number of S&E migrants has been admitted to the U.S. and, as the system/policy is currently structured, will continue to admit large numbers of immigrants. At the same time, there is little evidence that our educational pipeline produces too few domestic students able and willing to pursue an S&E career. And employment opportunities in most S&E occupations, particularly due to two recent recessions, are not as strong as they should be to attract more

domestic workers. Economists tell us that tighter labor markets induce wage gains and, in turn, more domestic residents would be retained all through the pipeline.

Today's admission system is faulty, however, and shy of a complete redesign, targeted changes should be made. I suggest three principles that should inform policy and regulatory changes.

First, changes should be careful not to artificially induce significantly increased admissions of foreign S&E workers. America's competitive advantage is best served by spurring domestic demand. It is not a good idea to create new visas or expanded caps, escalating caps, or cap exemptions. Nor is it a good idea to award automatic greencards which has the additional downside of creating the wrong incentives to, for example, pursue specialized education in the United States. Neither does it make sense to expand temporary programs, particularly those with long stays and no screening for intent to stay, without a corresponding capacity to permit adjustments to permanent status.

Second, uniquely innovative people are not common and policy should be selective; it should use incentives to admit immigrants who are the best and the brightest. Getting this formulation right is a difficult quest as we know so little about what works. Comparisons to systems in other countries are problematic not only because other countries are not first in skilled migrants preference queue as we are, but also because evidence does not support casual assumptions that point systems say work better than our system. A different system would keep employers in the driver's seat but provide different mechanisms for admitting migrants. For example, the Jordan Commission and, more recently, economists have weighed in favor of market-oriented admissions. One idea is to try truly temporary 2-3 year visas that are awarded in quarterly and spot auction markets on a pilot basis. Entrepreneur visas, that require benchmark investments for new graduates or temporary visaholders, are another good idea. And, given the evidence, we might want to target those with a track record than casting a wide, loose net for young graduates who might, someday, become successful entrepreneurs.

Third, policy should be as fair as possible. Today's system has put many good candidates in an admission backlog, while frustrating employers' need for timely resolution of workers' employment status. There is a sizeable backlog of greencard applicants for employment based visas. We and their employers have invested in these workers' skills and they desire to remain and work in the United States. Clearing that backlog, allocating unused employment visas from past years or by some other means, makes sense. There are many ideas on how to improve policy, in which the Committee is well versed, and my purpose here is not to detail specific recommendations but rather to present evidence for making informed decisions and a few principles to frame those decisions.