Science and Security

National Science Board

July 18, 2019

A. Bienenstock

To maintain leadership we must actively ensure

- Strong scientific programs
  - **Effective funding**
  - **The best scientists**
  - Openness in research
  - **The best collaborators**
- Timely knowledge of active research and advances in the rest of the world – cannot be caught by surprise
  - **Collaborations**
  - Full participation at national and international meetings
- **Strong STEM workforce at all levels**
- Appropriate security measures

Figure D1 -B

Regional share of worldwide R&D expenditures: 2000 and 2015

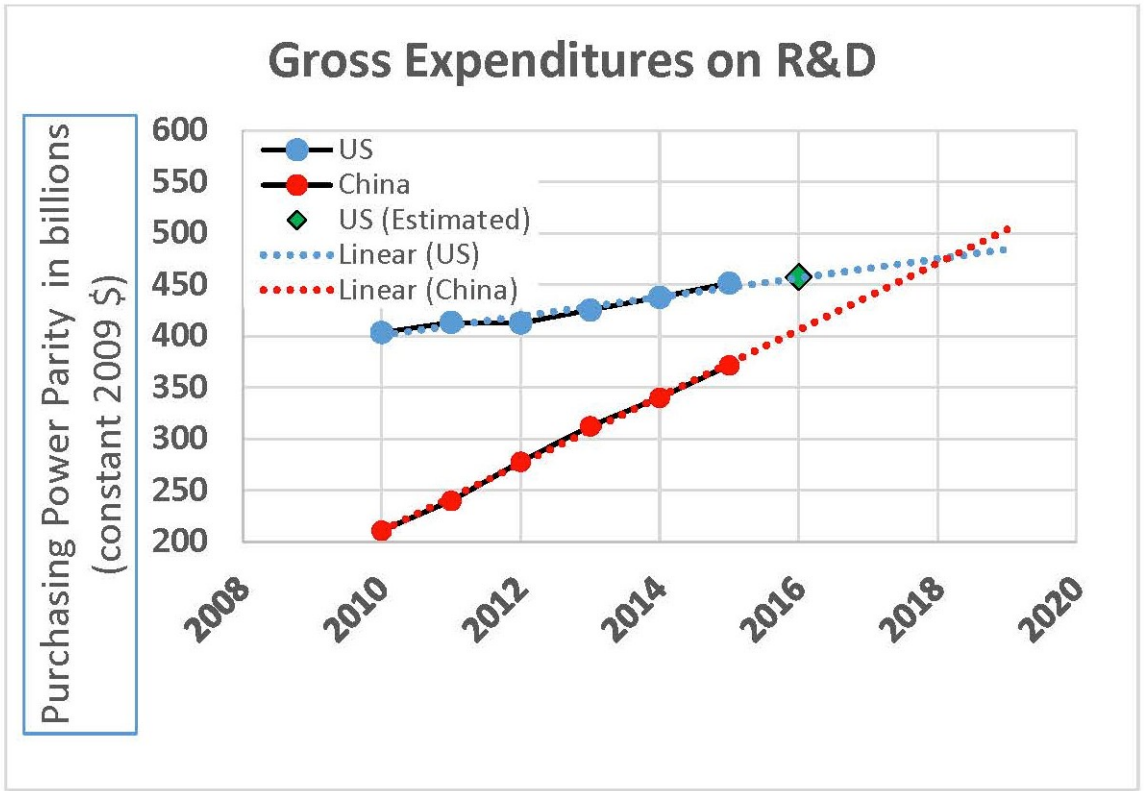
Note(s): East/Southeast and South Asia includes China, Taiwan, Japan, South Korea, Singapore, Malaysia, Thailand, Indonesia, Philippines, Vietnam, India, Pakistan, Nepal, and Sri Lanka.

Indicators 2018 : Cross-National Comparisons of R&D Performance, Chapter 4.

NATIONAL SCIENCE BOARD STATEMENT
ON GLOBAL RESEARCH AND DEVELOPMENT (R&D) INVESTMENTS

If current trends continue, the National Science Board expects China to pass the United States in R&D investments by the end of this year.

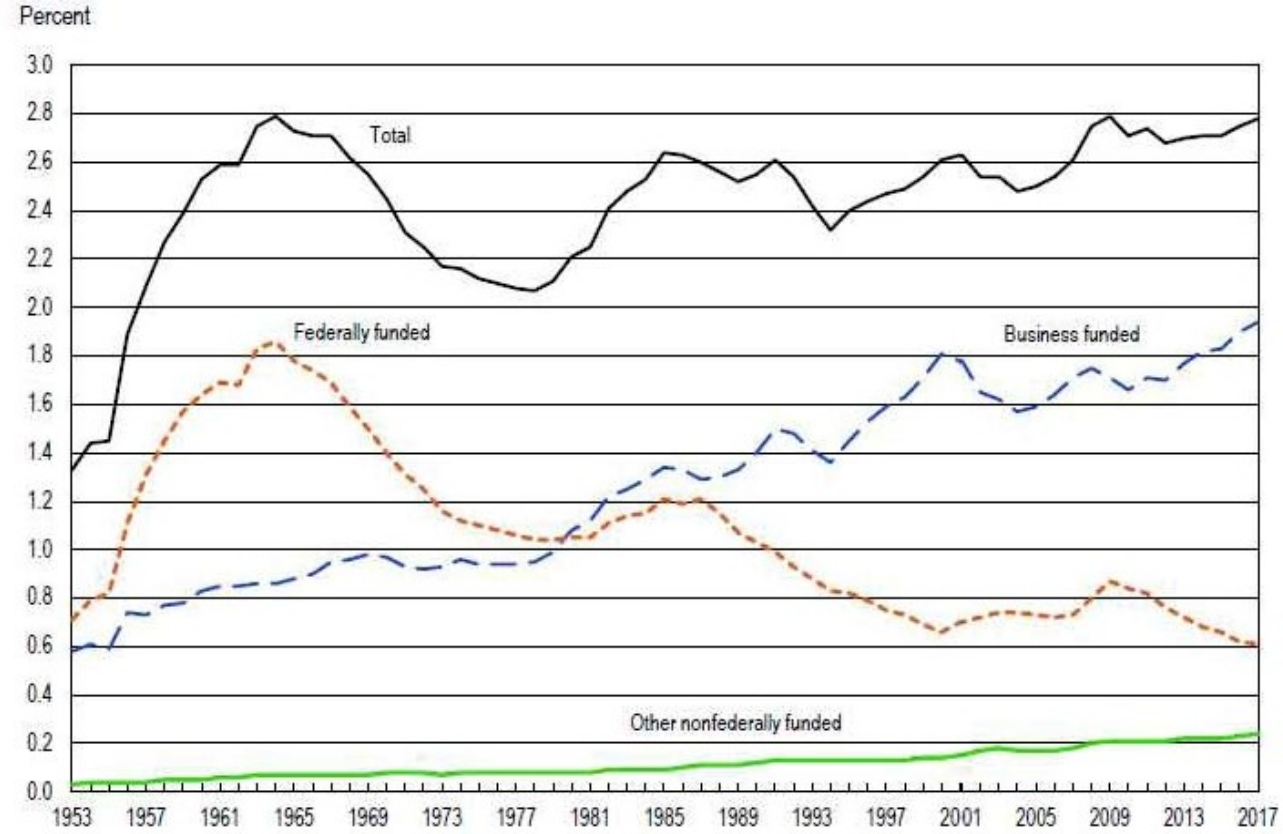
Taken from Augustine/Lane Letter to House Science Committee 4/26/19



Data from: *Science and Engineering Indicators 2018*

US 2016 Estimate from NSF, NCSES National Patterns of R&D Resources, 2017

FIGURE 2. Ratio of U.S. R&D to gross domestic product, by source of funding for R&D: 1953–2017



GDP = gross domestic product.

federal government as a funder of R&D by all performers; similarly for the business funded data. The other nonfederal category includes R&D funded by all other sources-mainly, higher education, nonfederal government, and other nonprofit organizations. The GDP data used reflect BEA's comprehensive revisions of the National Income and Product Accounts of August 2018.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

Figure 2 Source Data: Excel file (/statistics/2019/nsf19308/np16-tb-19308-fig002.xlsx)

Figure 5-26

Share of S&E articles internationally coauthored, by selected region, country, or economy: 2006 and 2016

Note(s): Articles refer to publications from a selection of journals, books, and conference proceedings in S&E from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating country or economy is credited with one count). Articles with international institutions are counts of articles with institutional addresses from more than one country or economy. See Appendix Table 5-42.

Source(s): National Science Foundation, National Center for Science and Engineering Statistics; SRI International; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed July 2017.

Science and Engineering Indicators 2018

Country Share of US International Articles 2016

- China 22.9% (~9% of all US articles)
- United Kingdom 13.4%
- Germany 11.2%
- Canada 10.2%
- France 7.5%

Observations

- International collaboration is now a major factor in S&T
  - Scientist collaborate in order to accomplish things that they cannot accomplish alone
    - Odds are significant that the best person is outside the US
  - Quality of science is improved markedly
    - Citation rankings of Stanford international collaboration papers much higher than Stanford average (Field-Weighted Citation Impact)
- Collaboration between US and Chinese scientists is significant
  - Greater than with any other country
- Important to understand.
  - Is it an important aspect of US research?

Collaboration of highly honored Stanford faculty member with China

- Chinese collaborators provide scientifically important materials that cannot be obtained domestically
- US academia does not reward incremental materials improvements, only new materials
- China has large numbers of scientists that can focus on this

- *Condensed-Matter and Materials Physics: The Science of the World Around Us – National Academy Press*
  - **"The primary focus of the nanocenters is on the creation of new materials** as well as on the advanced characterization of materials, while the other major facilities deal primarily with advanced characterizations."
  - "**Researchers at many institutions face challenges associated with the availability of materials."**

Some Questions and a Recommendation

- Will restrictions of collaborations make the US less competitive in the very fields that are important to us?
  - Limit our ability to collaborate with the best
  - Limit our knowledge of what the rest of the world is doing?
- Will restrictions on personnel have a similar effect?
- Will some proposed policies shift Chinese scientists to collaborate primarily with Europe, creating a bloc that could move beyond us and endanger our economic and military security?

- **Any restrictions on collaborations should be done on a grant-by-grant basis after careful consideration of potential consequences.**

NSTC STEM Workforce Report - 2000

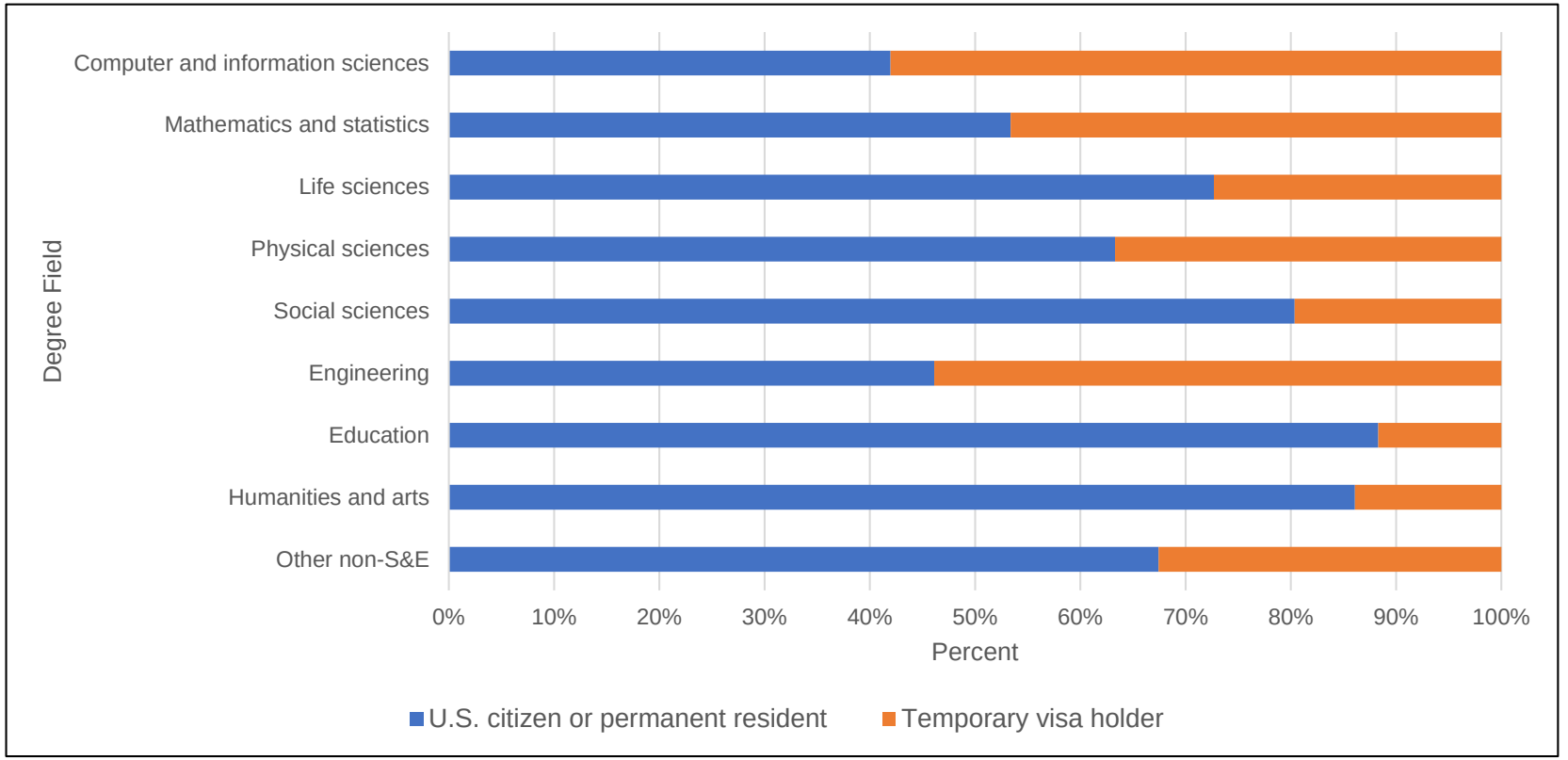
- **If** participation rates of all the groups remain the same and Census Bureau's demographic projections are correct,
- **then** fraction of workforce that is ST&E will decrease significantly in coming years.
- Must remain attractive for immigration
- Must increase participation rates of all groups in ST&E
- Under-represented minorities, women and persons with disabilities represent largest potential pools

Gap in Supply of STEM Workers

- STEM jobs posted for each unemployed STEM worker
  - 2010 – 5.4
  - 2016 – 13
  - Reference - *Sizing Up the Gap in our Supply of STEM Workers*
  - New American Economy Research Fund – March 29, 2017
- STEM Worker Shortage at a Crisis, Survey Shows
  - U.S. News – August 23, 2018
- ANNUAL REPORT ON THE STATE OF THE DOE NATIONAL LABORATORIES – January, 2017
  - "**The Laboratories face several ongoing challenges related to inclusion and diversity, including maintaining critical skills as the Laboratories' workforce ages**, particularly in areas that are both core and unique to DOE (e.g., stockpile stewardship and accelerator design), and in training of students, postdoctoral researchers, and staff for the continuing challenges in national security, science, and energy technology."

In 2017, foreign students earned the majority of U.S. doctorates awarded in computer science and engineering

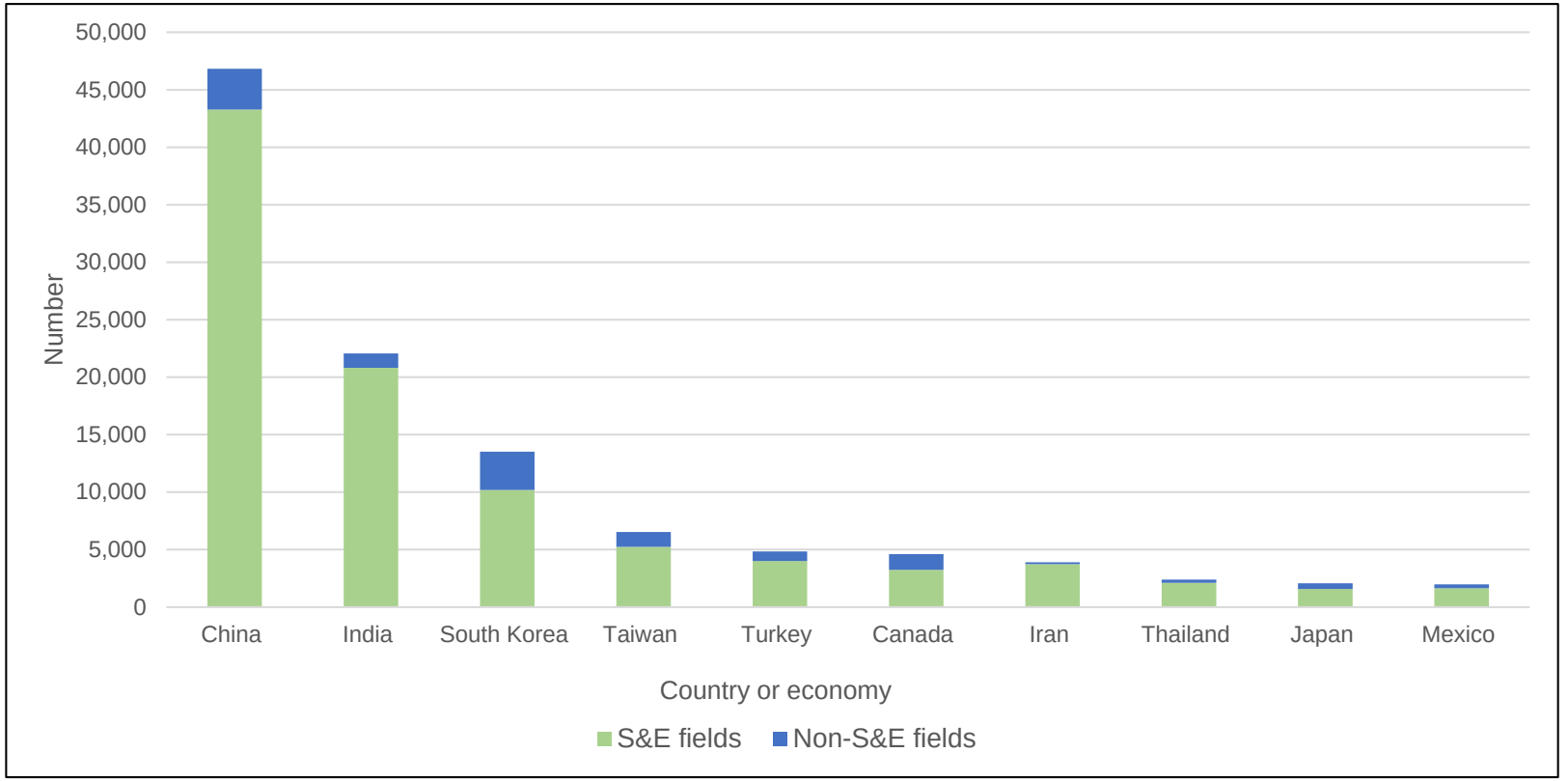
Citizenship of U.S. doctorates by degree field: 2017



Source: Survey of Earned Doctorates: 2017

Three countries account for over half (54%) of U.S. doctorates awarded to foreign students

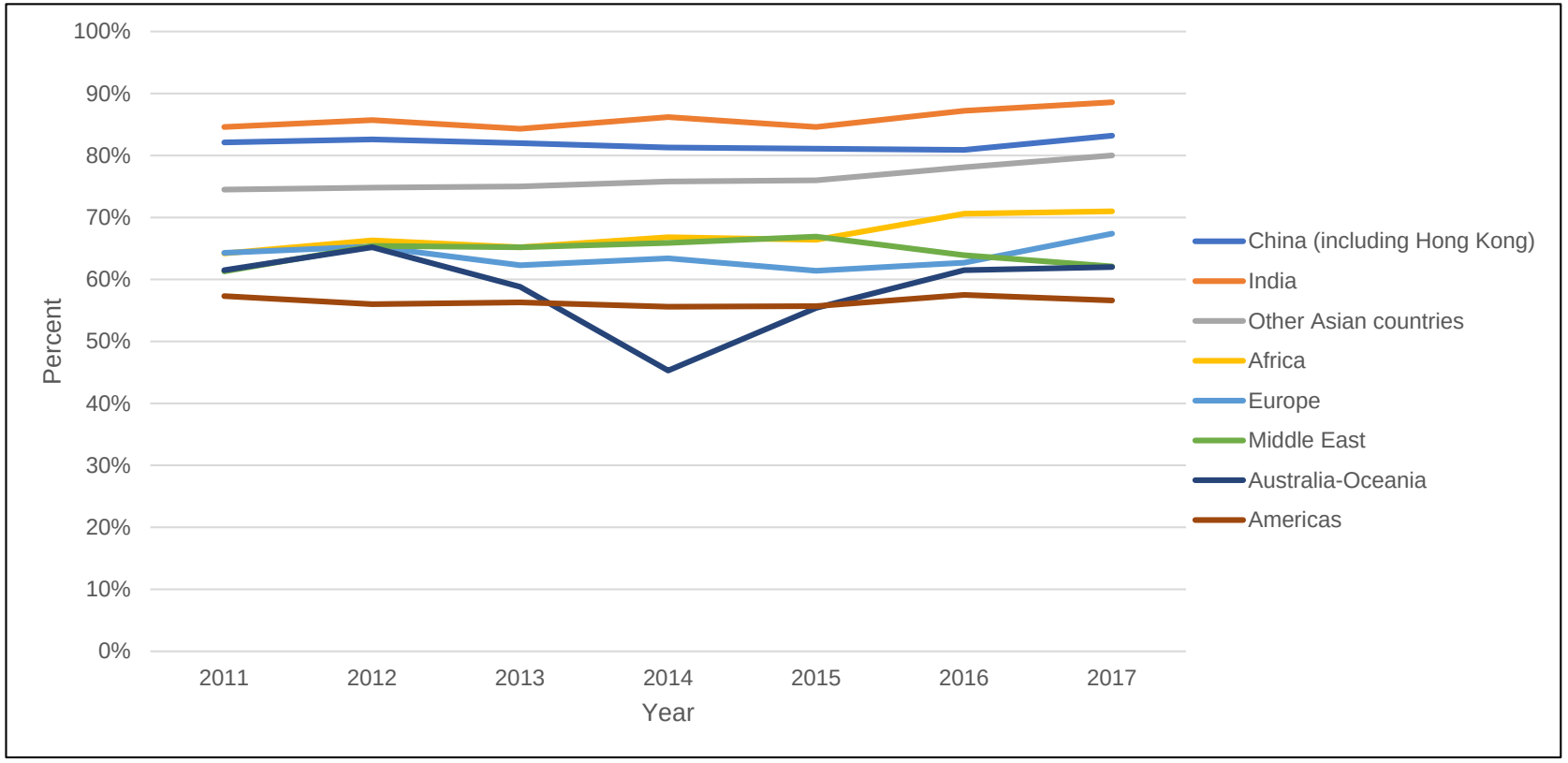
Top 10 countries or economies of foreign citizenship for U.S. doctorate recipients with temporary visas: 2008–17



Source: Survey of Earned Doctorates: 2008-2017

Doctorate postgraduation commitments for U.S. employment varies by country of citizenship

Doctorate recipients with temporary visas intending to stay in the United States after doctorate receipt, by country of citizenship: 2011–17



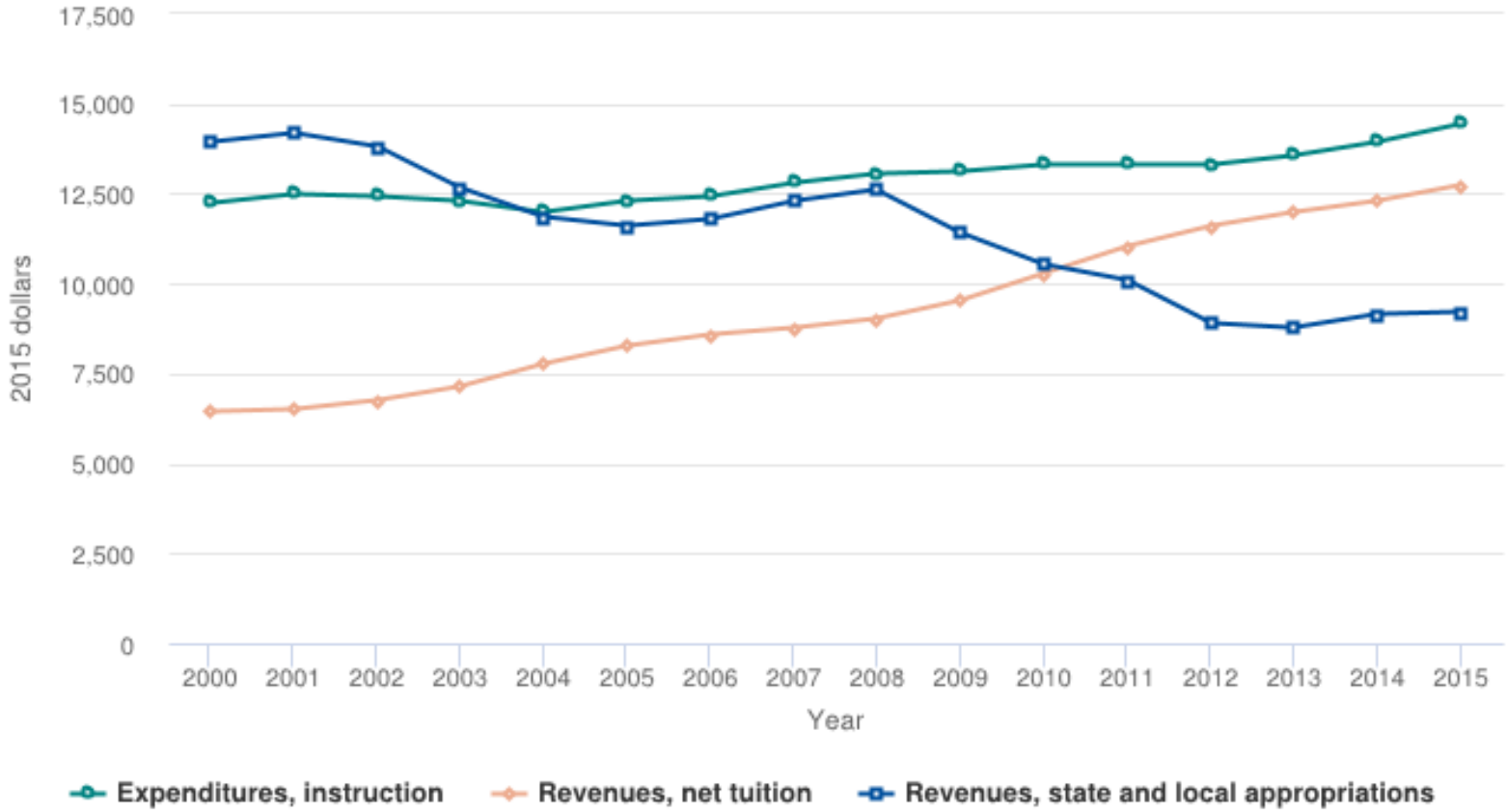
Source: Survey of Earned Doctorates: 2011-2017

Observations

- Chinese nationals are a very significant fraction of the US workforce in computer science, engineering and mathematics
- They are also significant in the earth, life and physical sciences
- The US is highly dependent on Chinese graduate students for its S&T workforce
- Note that China pays for education through undergraduate study
  - Particularly important as states reduce funding of public universities
- Some of the most creative and productive Stanford faculty in the physical sciences and engineering were born in China
- The decline in state funding of public universities increases our dependence on foreign students

Figure 2-1

Selected average revenues and expenditures per FTE at public very high research universities: 2000–15



FTE = full-time equivalent.

Source(s): Integrated Postsecondary Education Data System (IPEDS) Analytics: Delta Cost Project Database, 2000–15 (16-year matched set), special tabulations (2017).

Science and Engineering Indicators 2018

To Maintain Leadership the US Must

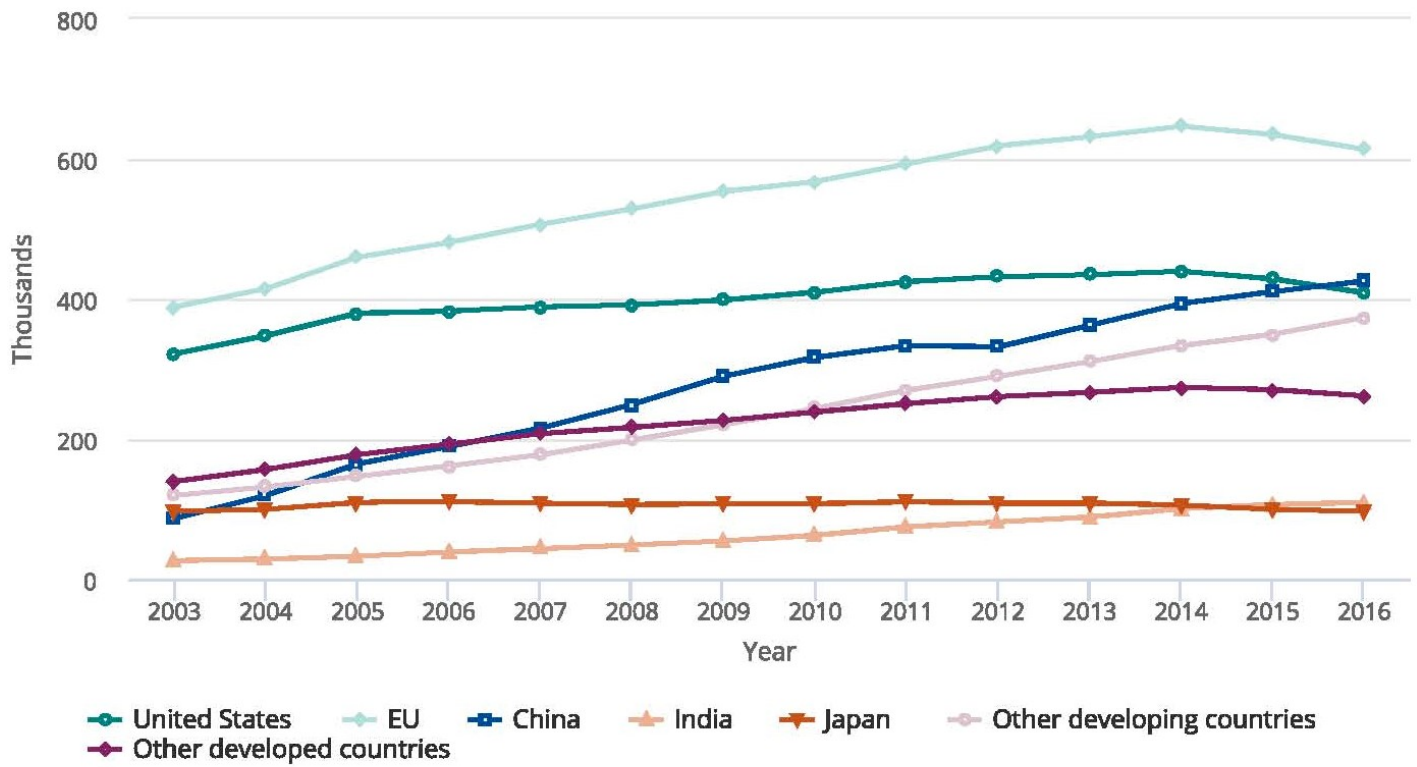
- Fund R&D well – cannot fall behind
- Maintain openness thoughtfully –
  - reaffirm NSDD-189 and maintain security thoughtfully
- Understand high level of collaboration with Chinese scientists and engineers
  - May be very important for critical fields
  - Keep us aware of Chinese research and advances
  - Restrict collaboration only when necessary
- Keep the country attractive for Chinese students, postdocs and those who want to remain in US
  - Openness of US academia is, I believe, important component
  - Visa process should be primary wall to those we don't want
  - Visa process should be sufficiently efficient so as to not discourage those we want from coming and staying
    - Return to 5 year visas
- Increase the supply of US STEM workers
  - New NDEA-type program?
  - Increased funding of public universities
    - Recognize public higher education as critical **public** good
- There is potential value to the US from those who return to China.

The End

Overview of the State of the U.S. S&E Enterprise in a Global Context

FIGURE O-8

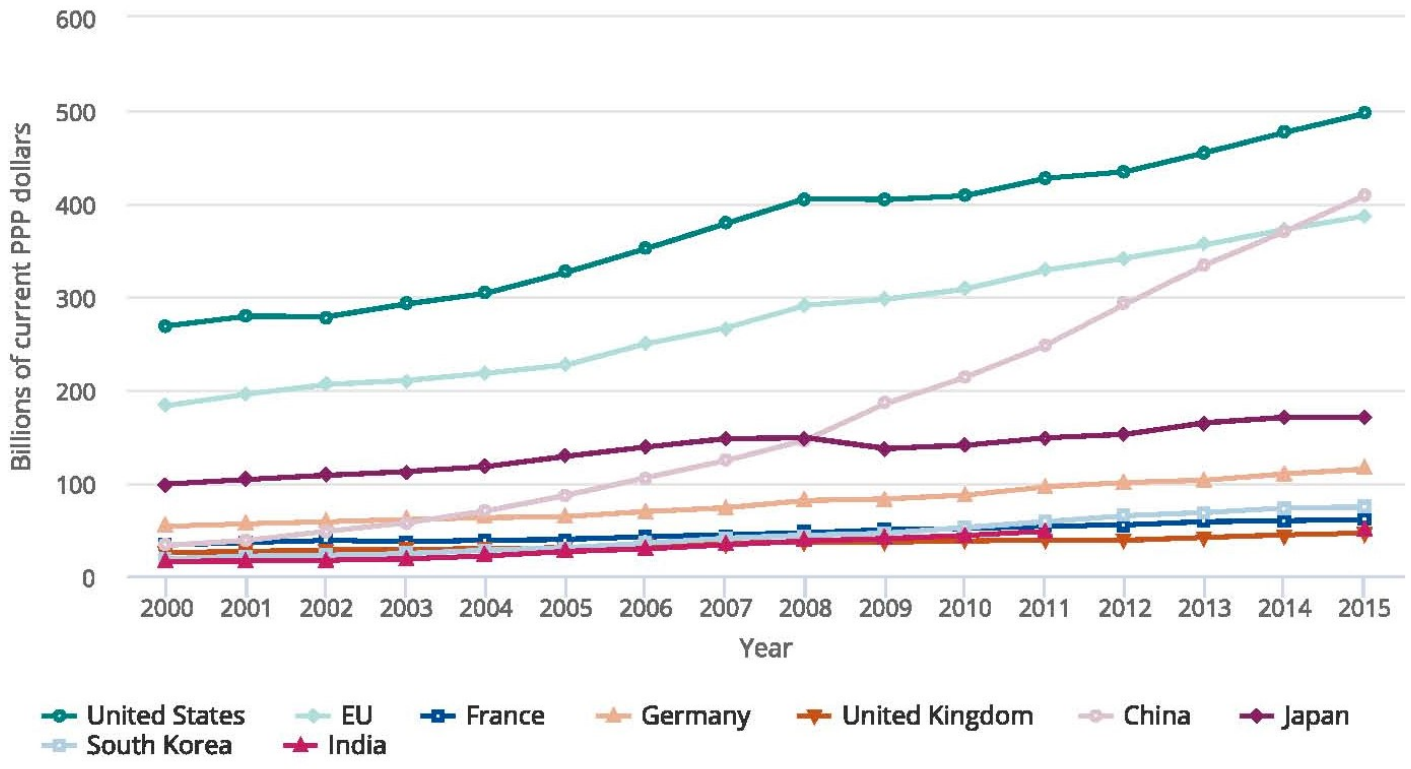
S&E articles, by selected region, country, or economy: 2003–16



Overview of the State of the U.S. S&E Enterprise in a Global Context

FIGURE O-6

Gross domestic expenditures on R&D, by selected region, country, or economy: 2000–15



EU = European Union; PPP = purchasing power parity.

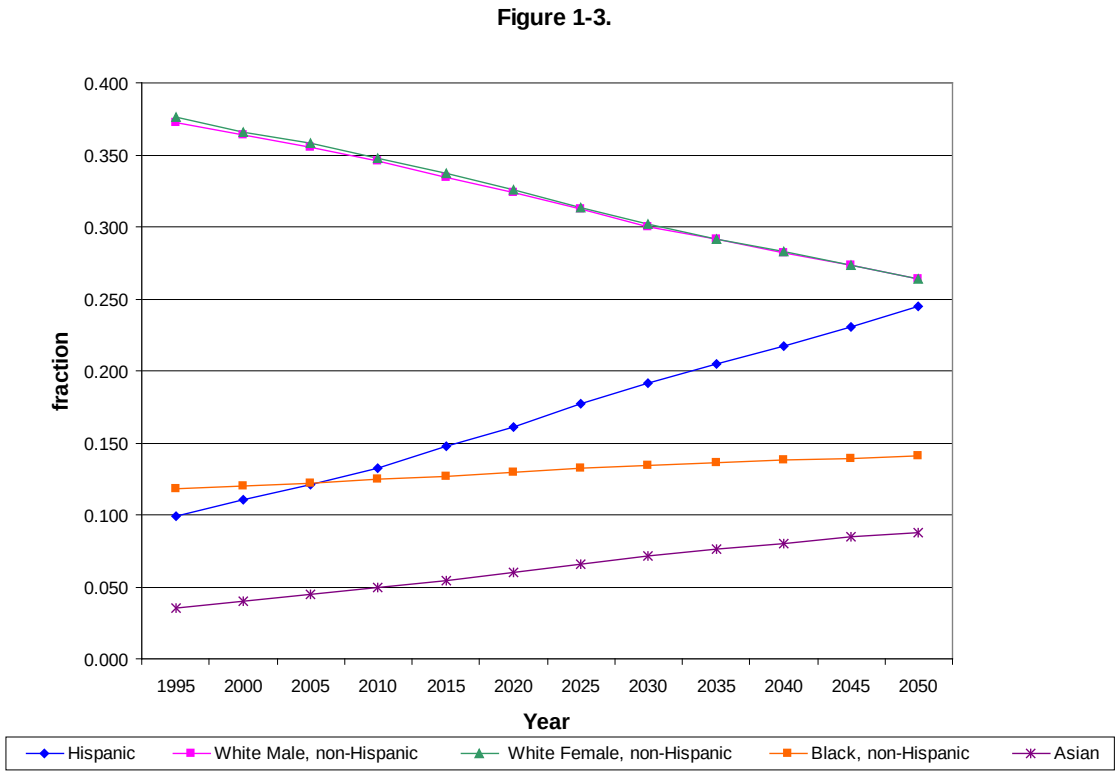
PHOTOGRAPHY

How Huawei and Leica made a camera phone so good, we ditched our DSLR

SHARE

Daven Mathies/Digital Trends

Bureau of the Census Demographic Projections - 18-64 year olds



Percent of 22 Year Olds Earning Science & Engineering Bachelor Degrees - 1995

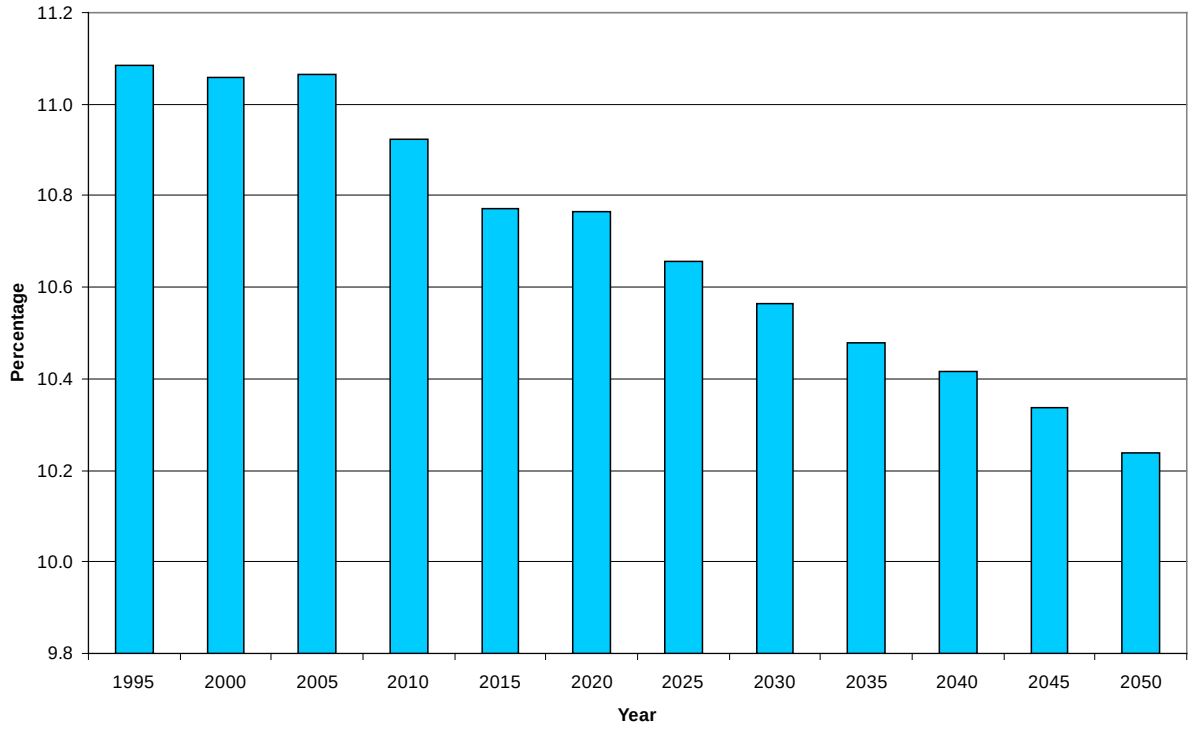
- African-Americans - 5.7
- Asians - 21.6
- Hispanic - 4.8
- non-Hispanic White Females - 11.8
- non-Hispanic White Males - 13.8

Projections of Future Situation

- **If** participation rates of all the groups remain the same and demographic projections are correct,
- **then** fraction of workforce that is ST&E will decrease significantly at time when increase is likely to be needed.

Calculated Fraction of 22 Year Olds Receiving Bachelors Degrees in Science & Engineering if Award Rates of Various Groups Remain Constant

Figure 1-4.



Immigration & the ST&E Workforce - 1995

- 12% of people in U.S. holding S&E bachelor's degrees were naturalized citizens or non-U.S. citizens
- Would have to increase immigration significantly to hold ST&E fraction of workforce constant if don't increase domestic participation rates
- Nations providing immigrants are building their own ST&E workforces and economies

National GDPs

- China - 12.24 trillion USD (2017)
- US - 19.39 trillion USD (2017)

People living in Poverty

- United States Census Bureau - 2017
  - 39.7 million
  - 12.3% of population
  - 15 million children
  - 21% of all US children
- China – estimates - 2017
  - ~30 million
  - ~2% of population

Population

- China - 1.386 billion (2017)
- US – 329 million (2019)