How Science Shapes Economics

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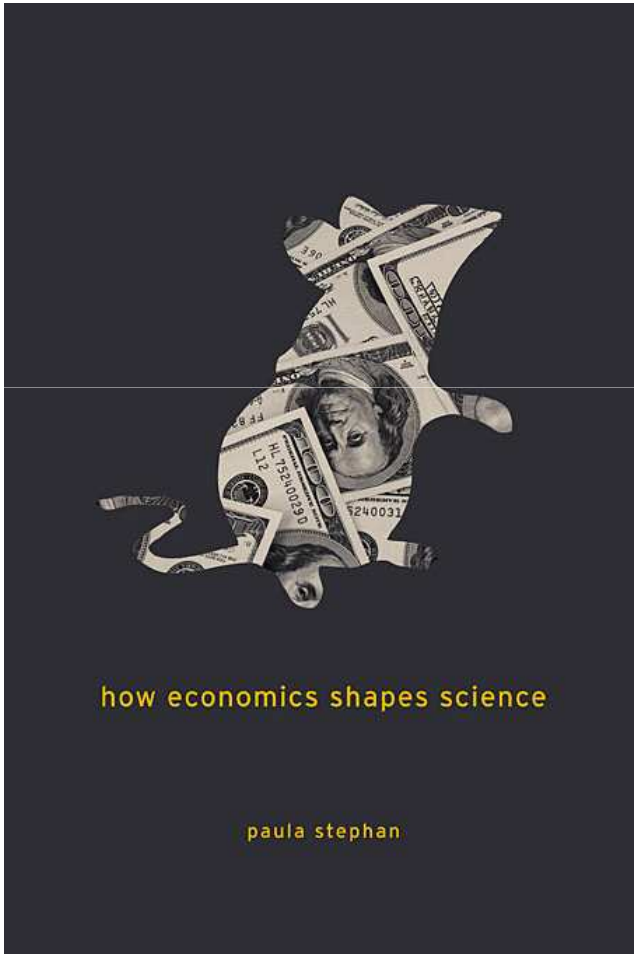
NBER

Presentation Based on book



Plan for Presentation

- What do we mean by successful research?
- What affects scientific productivity?
- Role of the foreign-born in scientific productivity, both in United States and in Europe

What Do We Mean by Successful Research?

- Ask a scientist, and they'll say research that their colleagues see as important, making a difference
- Often measured in terms of citations to published articles
  - Citation counting has become a big business—started with ISI but now Google Scholar, Scopus
  - New ways of counting, such as *h-index*—measures number of articles cited "h" or more times

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Hot Links:

- Highlights
- Nanotechnology
- Journal Covers
- Lab Tour
- CNCF
- Group Videos
- Group Meeting
- Group Memories

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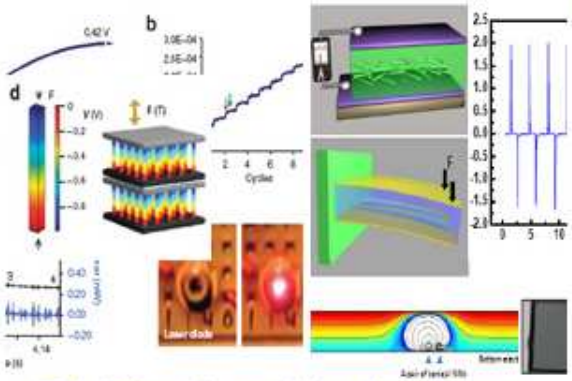
Web Nano Site



Z.L. Wang's publications have been cited over 40,000 times!

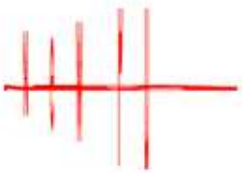
The publication H-factor is 95 !

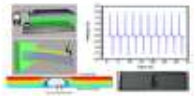
"Video of the week: Z.L. Wang on piezoeletronics and piezophotoeletronics. **(new!)**

We are a leading group in nanoscience and nanotechnology in Georgia Institute of Technology.

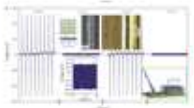
Our current research focuses on the fundamental science in the physical and chemical processes in

Selected Current Pub

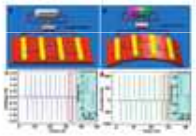




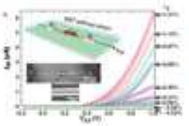
" High-Output Nanogenerator by Rational Unipolar Assembly of Conical Nanowires and Its Application for Driving a Small Liquid Crystal Display. **(new!)**



" Self-powered nanowire devices. **(new!)**



"Flexible High-Output Nanogenerator Based on Lateral ZnO Nanowire Array **(new!)**



" Strain-Gated Piezotronic Logic Nanodevices. **(new!)**

more...

Current News

Hot News: Prof. Wang has been elected as a foreign member of the Chinese Academy of Science **(new!)**

English Version

What Do We Mean by Successful Research?

- Ask an economist, and we'll say research that (eventually) has an economic impact
- Many examples, including GPS, MRI, laser, penicillin, treatment of HIV, integrated circuit, etc.
- Time between research and economic impact can be extremely long—and unpredictable.
  - Atomic clock as example—suggested more than 130 years ago; contributed to many new products and processes in recent years
  - Laser, when discovered, described as a "solution looking for a problem"
  - Important to realize there are many "dry" holes in sense that research may be promising but has no economic impact. Very common in drug discovery

What Do We Mean by Successful Research

- Ask public, and they may have a more global perspective.
  - They care about economic factors, but some also care about the “wonder” of scientific discovery—the joy of seeing pictures from outer-space, etc.

What Affects Scientific Productivity?

- Key inputs include
  - Scientists
    - Persistence
    - Skills
    - Knowledge—often comes by collaborating with others
  - Equipment
    - Sequencing machines, telescopes, colliders, scanners
  - Materials, including animal models

Mice

Material

- Mice are king when it comes to research
- 90% of all animal models used in research are mice
- Over 30 million in use

Why a Mouse on Cover of Book?

- Book explores how incentives and costs affect practice of science in public research organizations
- And mice are a perfect example of how costs affect practice of science
  - At least 30 million mice currently being used in research
  - Expensive—off the shelf costs around $40, but designer mice, such as onco mice, can easily cost $3,500 to create
  - Keeping mice is expensive—in France, costs about .40 € per week per mouse. If you have 20,000 mice quickly adds up to 400,000 € a year.
  - Play an important role in discovery: recent example of “tau” protein and Alzheimer's disease
  - Nobel prizes have been awarded in recent years to individuals who have “designed” innovative mice

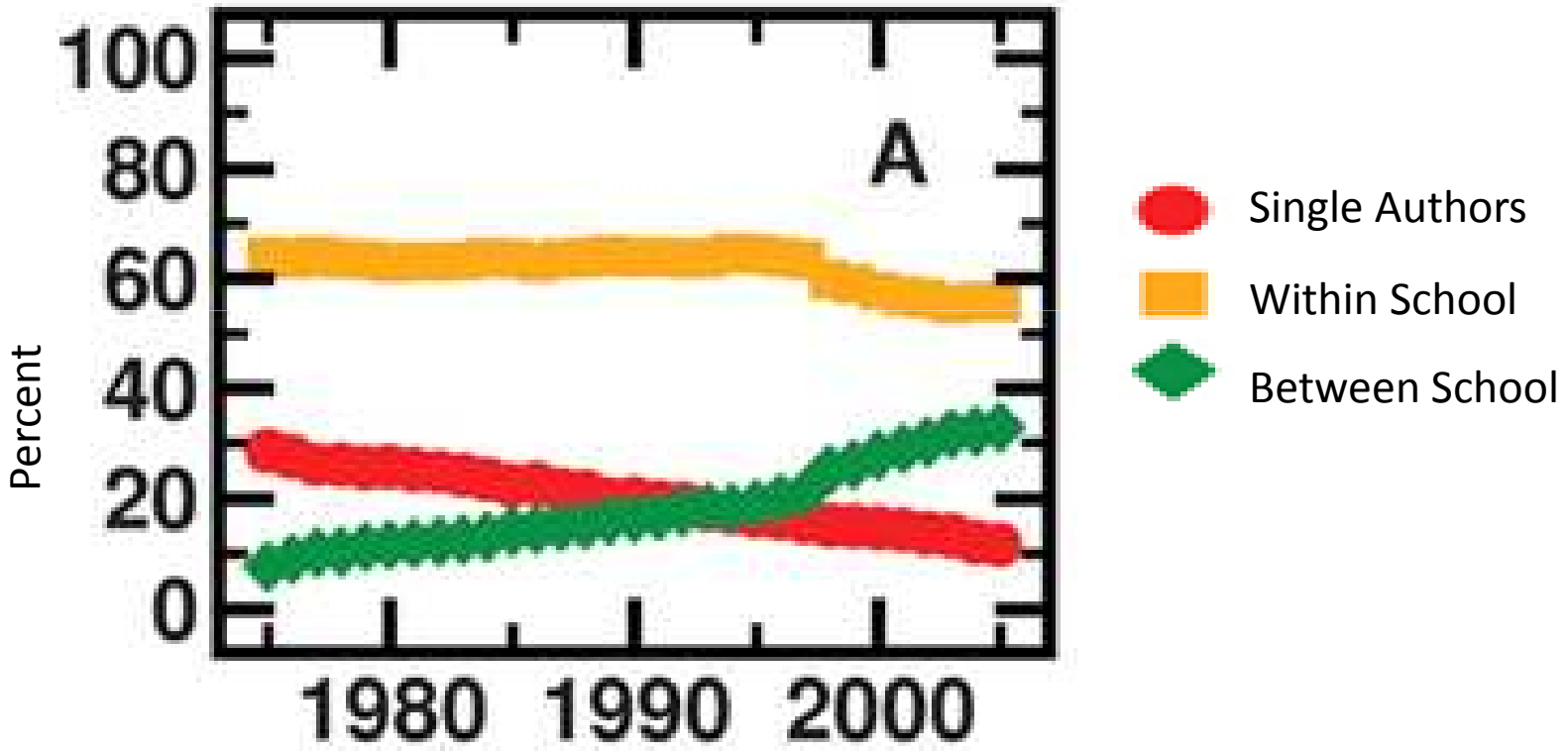
Location of Research

- Majority of basic research in U.S. is performed in universities; in Europe considerable amount of basic research is performed at universities but also in public research organizations such as CNRS
- Some performed at large facilities, such as CERN
- Funding for much of this research—but not all of it—comes from governments.
  - In U.S., government contributes $55 billion a year to university research and development
  - Rationale is the public nature of knowledge—that is that knowledge, once created and shared is not “used up” when used and individuals cannot be excluded from it.

Scientists

- A key input in producing research are people—the scientists. They bring
  - Cognitive reasoning, intelligence, knowledge
  - Skills, including tacit skills (magic hands),
  - Few scientists possess wide enough scope of knowledge or skills
    - Collaboration has become increasingly common in science
    - Considerable evidence that collaborative research is “better”

The Rise in Multi-University Collaboration, Science and Engineering



Source: B. F. Jones et al., Science 322, 1259 -1262 (2008)

Role of Foreign Born in U.S. Science

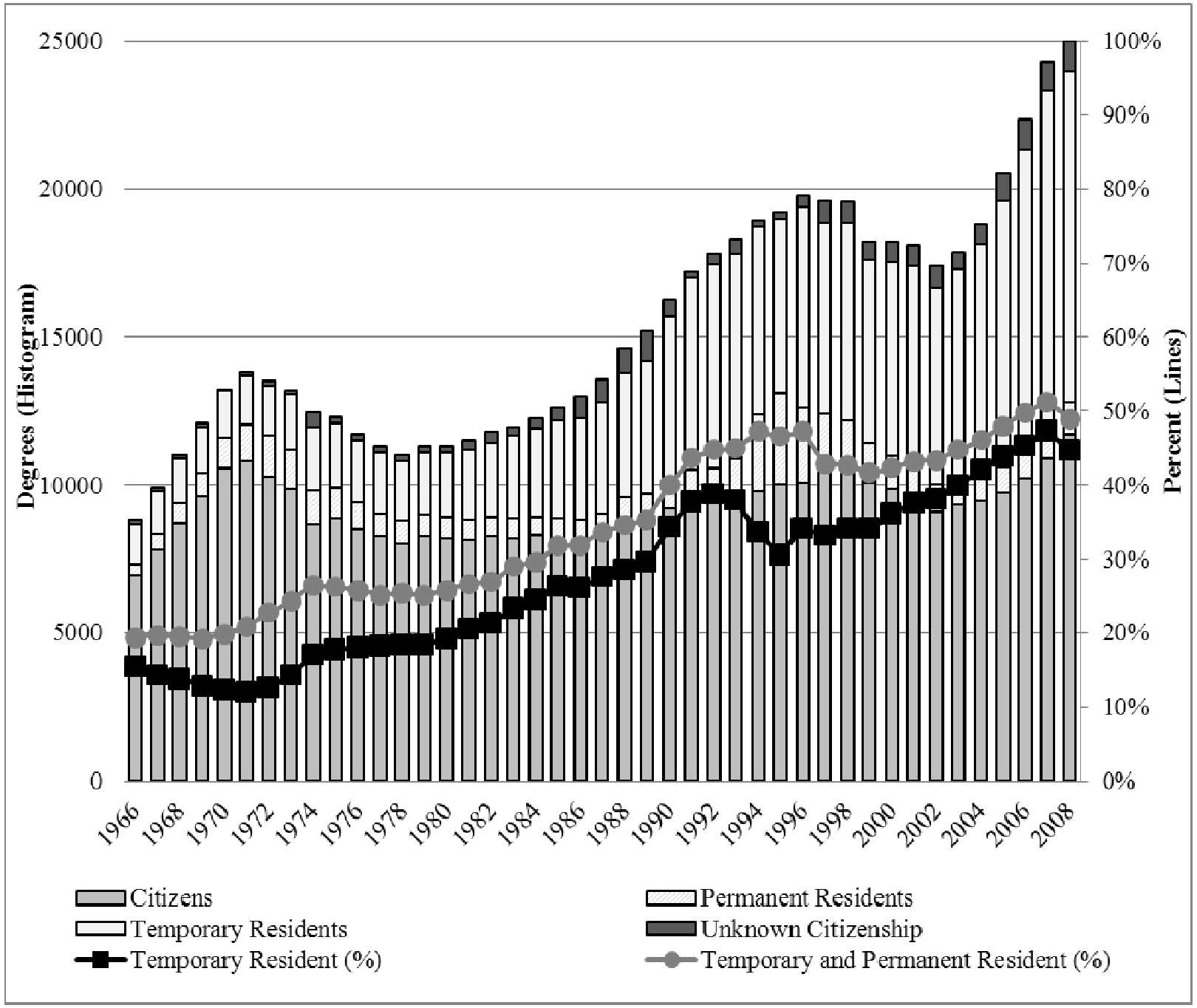
- Large number of scientists and engineers in the U.S. are foreign born
- Some come as graduate students
- Some come as postdocs, having received their PhD training outside the U.S.
- Some come after establishing a career elsewhere—large inflow of Soviet mathematicians to U.S. in last twenty years is a case in point.

Percent of Faculty who Are Foreign Born at U.S. Universities and Colleges by Field for individuals who received a PhD at a U.S. University

Field	1979	1997	2006
All fields	11.7	16.3	21.8
Engineering	17.5	28.4	34.9
Life Sciences	10.0	12.1	15.5
Biological Sciences	8.9	10.5	15.2
Earth/environt	10.3	12.4	14.7
Physical Sciences	10.7	17.8	18.1
Chemistry	9.5	11.6	14.6
Math/C.S.	10.4	24.5	31.4
Physics & astronomy	12.4	17.7	23.3

Foreign-born Graduate Students

- Large and increasing presence
- Funding comes from grants and fellowships
- Biggest source country is China
- Followed by India and Korea
  - Tsinghua University in Beijing sent more students to graduate school in U.S. than any other institution, followed by Peking. Seoul national 4th place. Third place goes to University California-Berkeley; Fifth to Cornell University


25000
20000
15000
10000
5000
0
Degrees (Histogram)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent (Lines)
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Citizens
Permanent Residents
Temporary Residents
Unknown Citizenship
Temporary Resident (%)
Temporary and Permanent Resident (%)

Postdocs

- Large and important role at U.S. research institutions
- Funding comes from government grants and fellowships
- Foreign-born play a large role

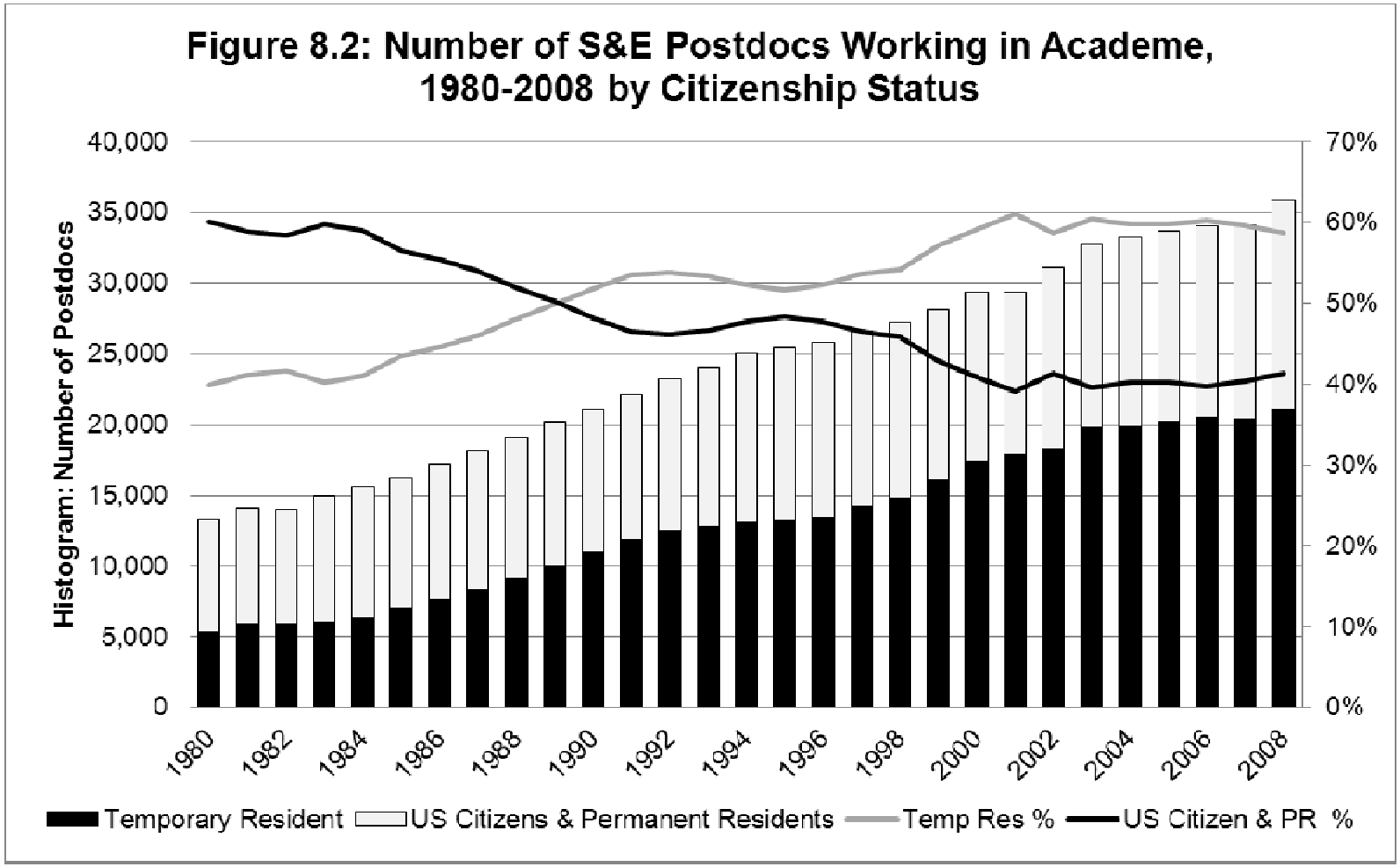


Figure 8.2: Number of S&E Postdocs Working in Academe, 1980-2008 by Citizenship Status
Histogram: Number of Postdocs
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
70%
60%
50%
40%
30%
20%
10%
0%
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Temporary Resident
US Citizens & Permanent Residents
Temp Res %
US Citizen & PR %

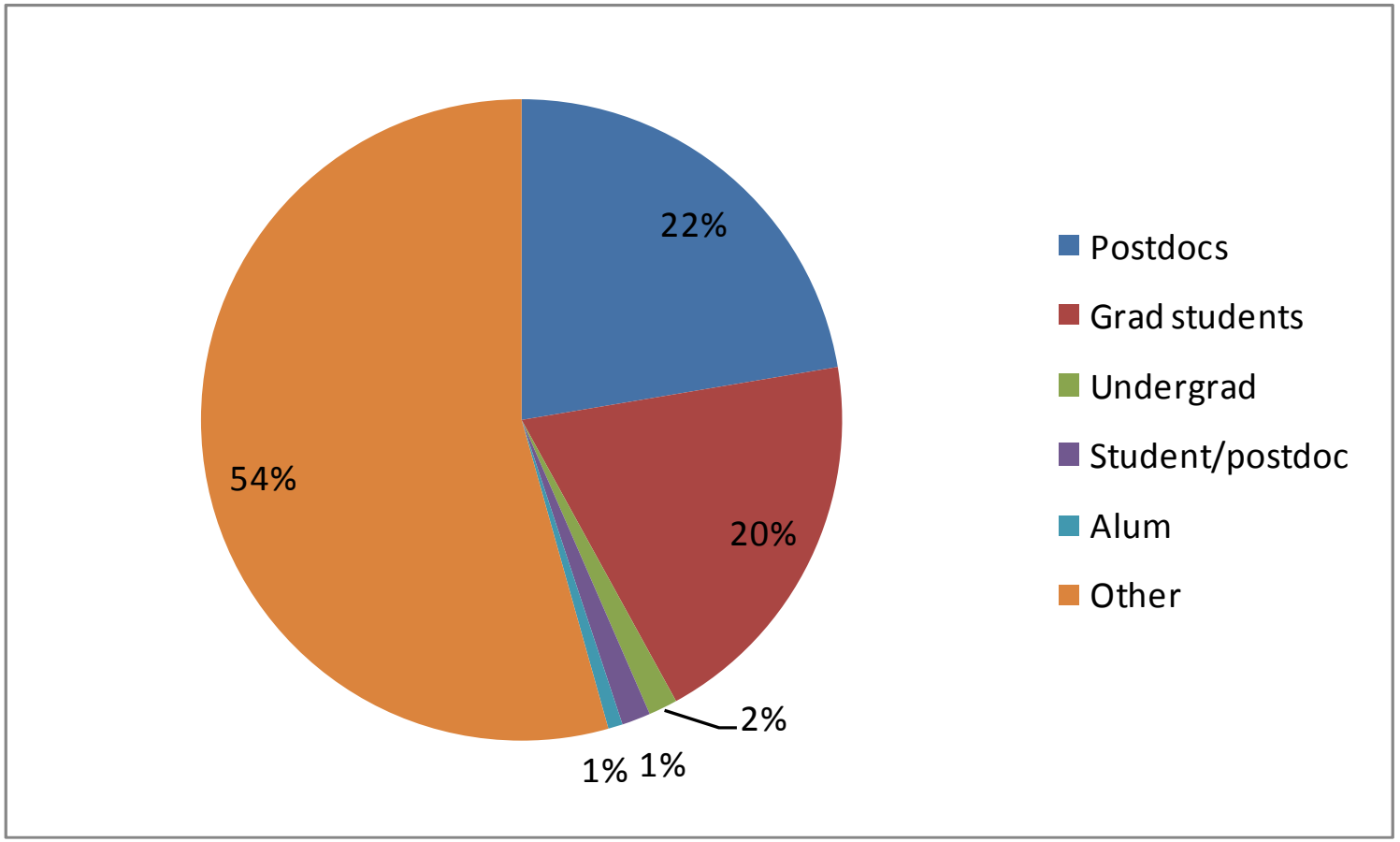
Study of Articles in *Science*

- Collect data for 22 issues—Nov. 2, 2007 to May 2, 2008.
- Restrict analysis to papers with last author affiliated with U.S. academic institution.

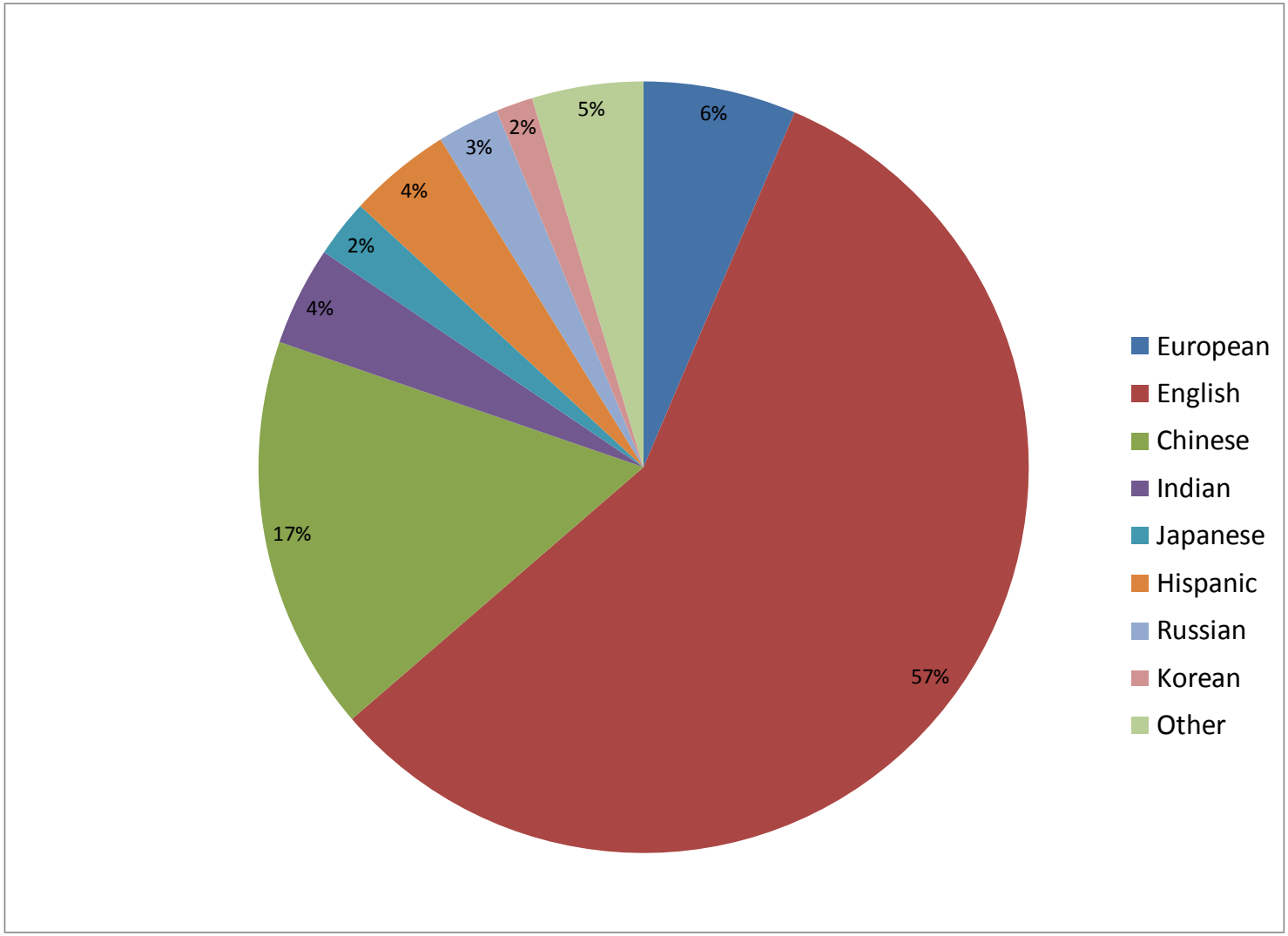
Choose *Science*

- Multidisciplinary
- Leading journal
- Highly selective: 6.6% acceptance rate in 2007
- Fast turnaround time

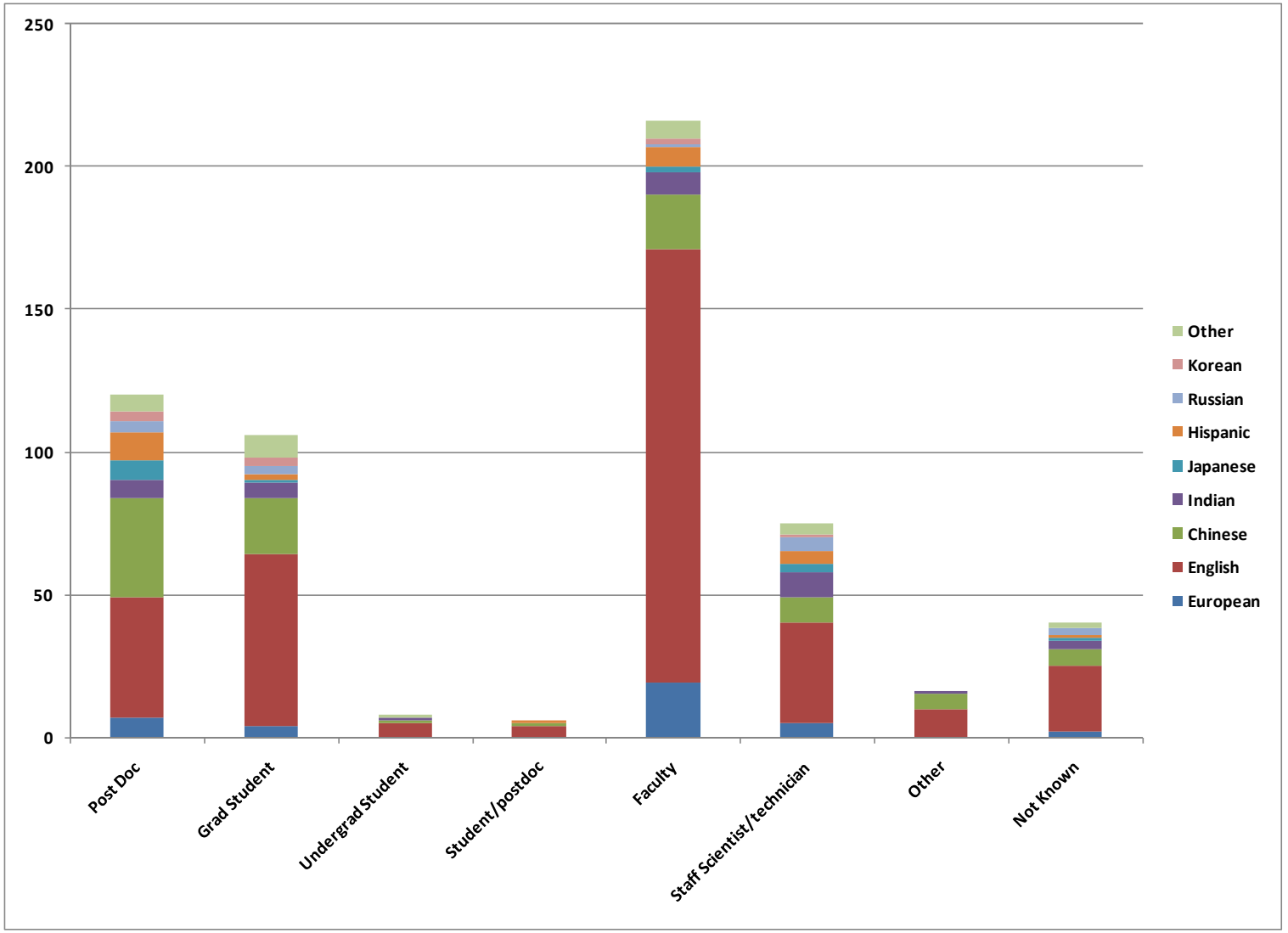
Authorship Patterns U.S. Articles with Fewer than 10 authors



Ethnicity of U.S. Authors, Papers with less than 10 authors



Ethnicity by Position: Papers with Less than 10 Authors



Are Foreign Born Disproportionately Productive?

- Rationale for hypothesis
  - Selection
  - Persistence/motivation
  - Mobility enhances productivity through "matching"

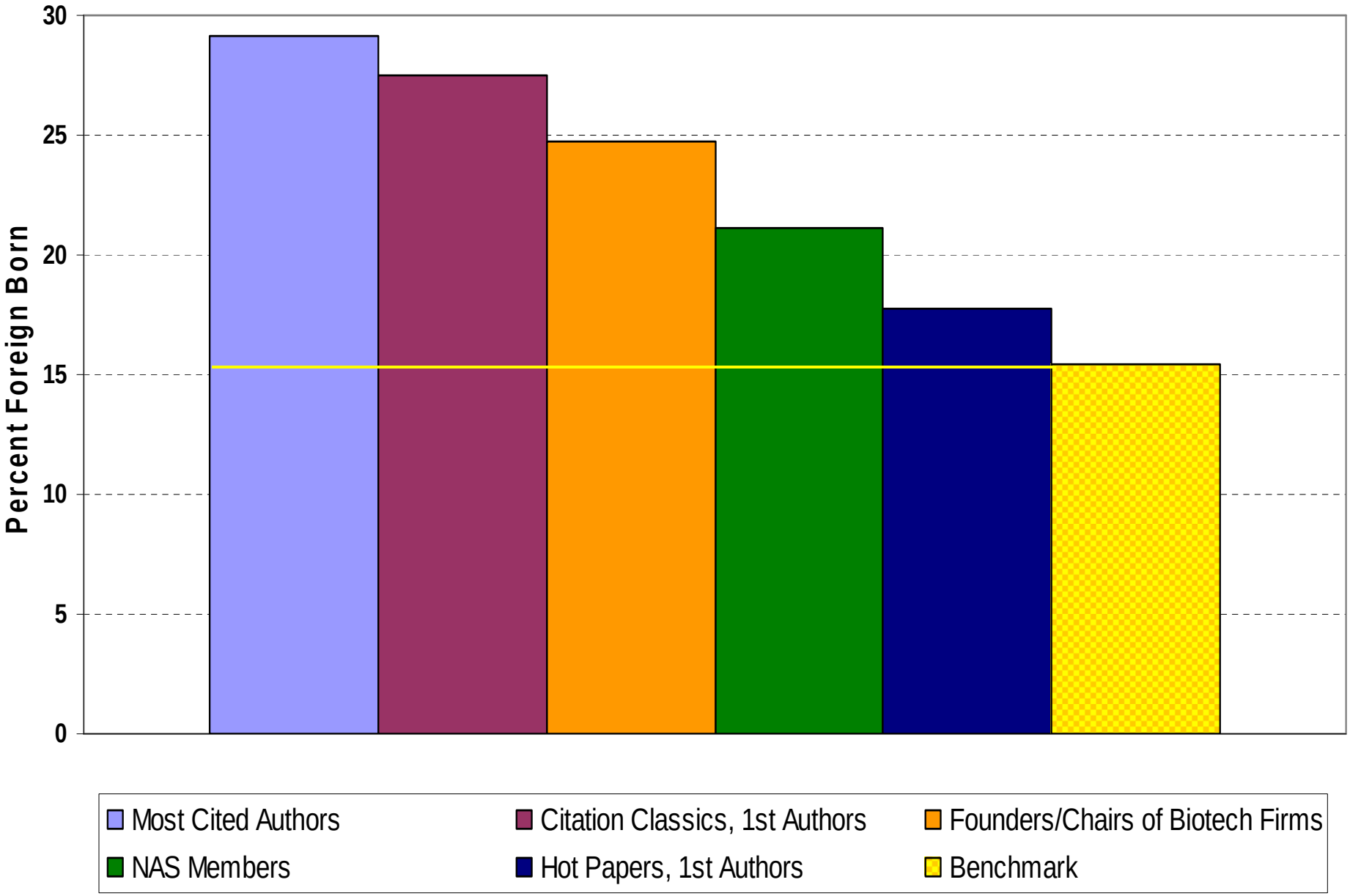
Recent Evidence for Chemists

- Chemists who received PhDs in the United States during 1999-2008
- Compared to others in their cohorts, those with Chinese names were first author on a significantly larger number of papers than non-Chinese

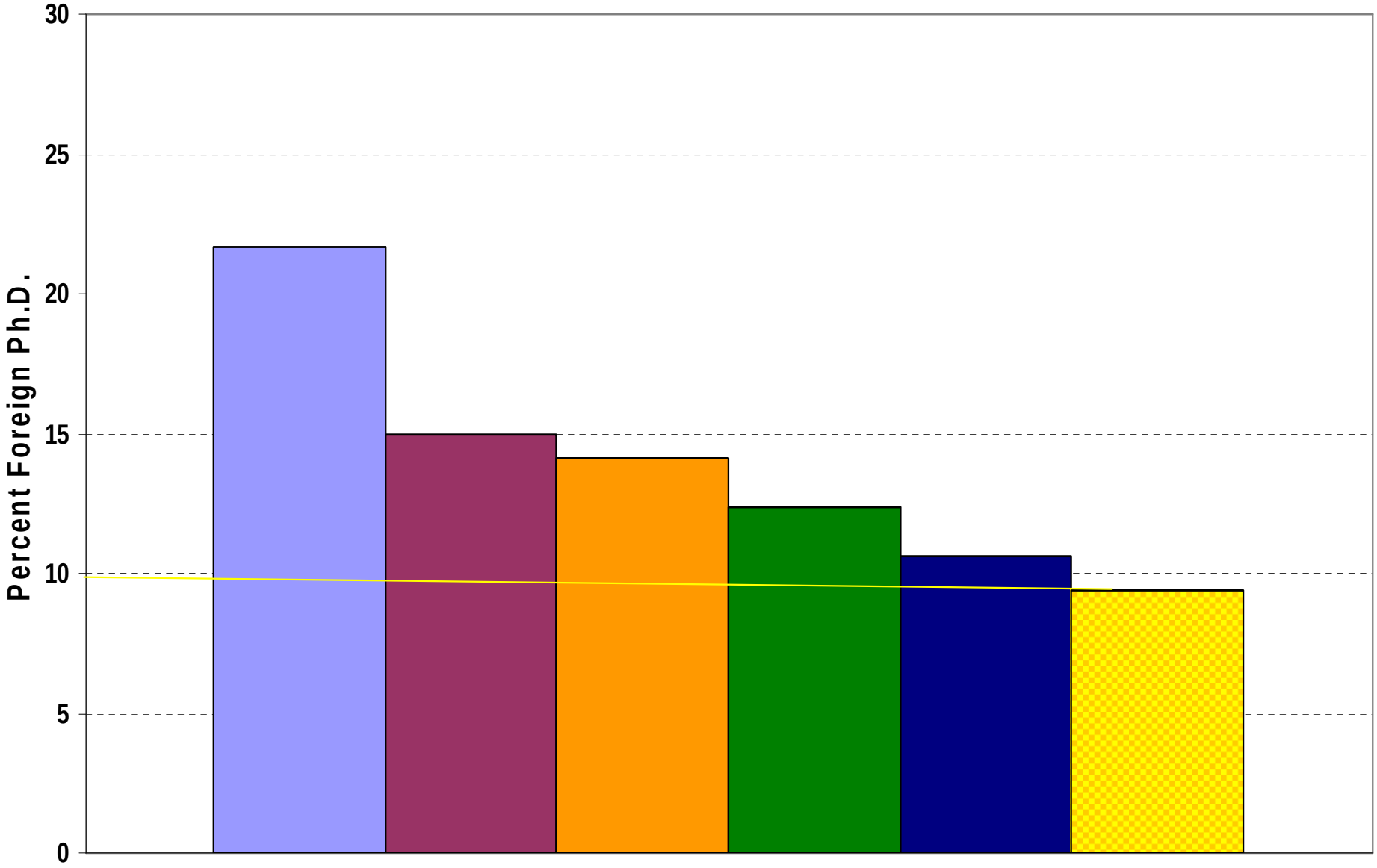
Earlier Evidence

- Study of exceptional contributions of scientists and engineers, conducted in the 1990s
- Compare percent of scientists in U.S. foreign born or foreign educated with percent making
- Exceptional contributions defined as
  - Highly cited authors
  - Membership in National Academy
  - Citation Classics
  - Founders of companies
  - Hot papers

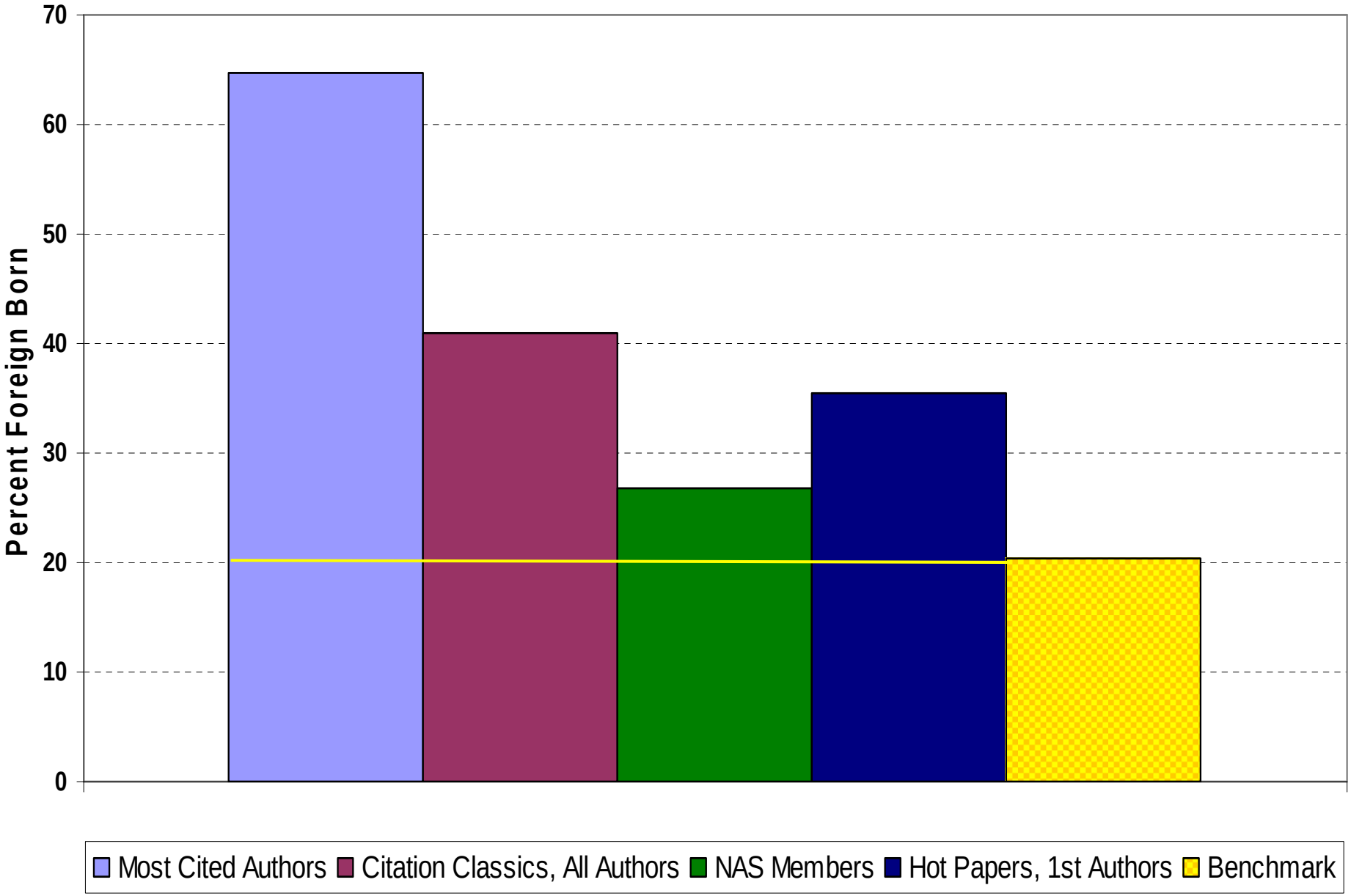
Scientists Making Exceptional Contributions in U.S. Life Sciences



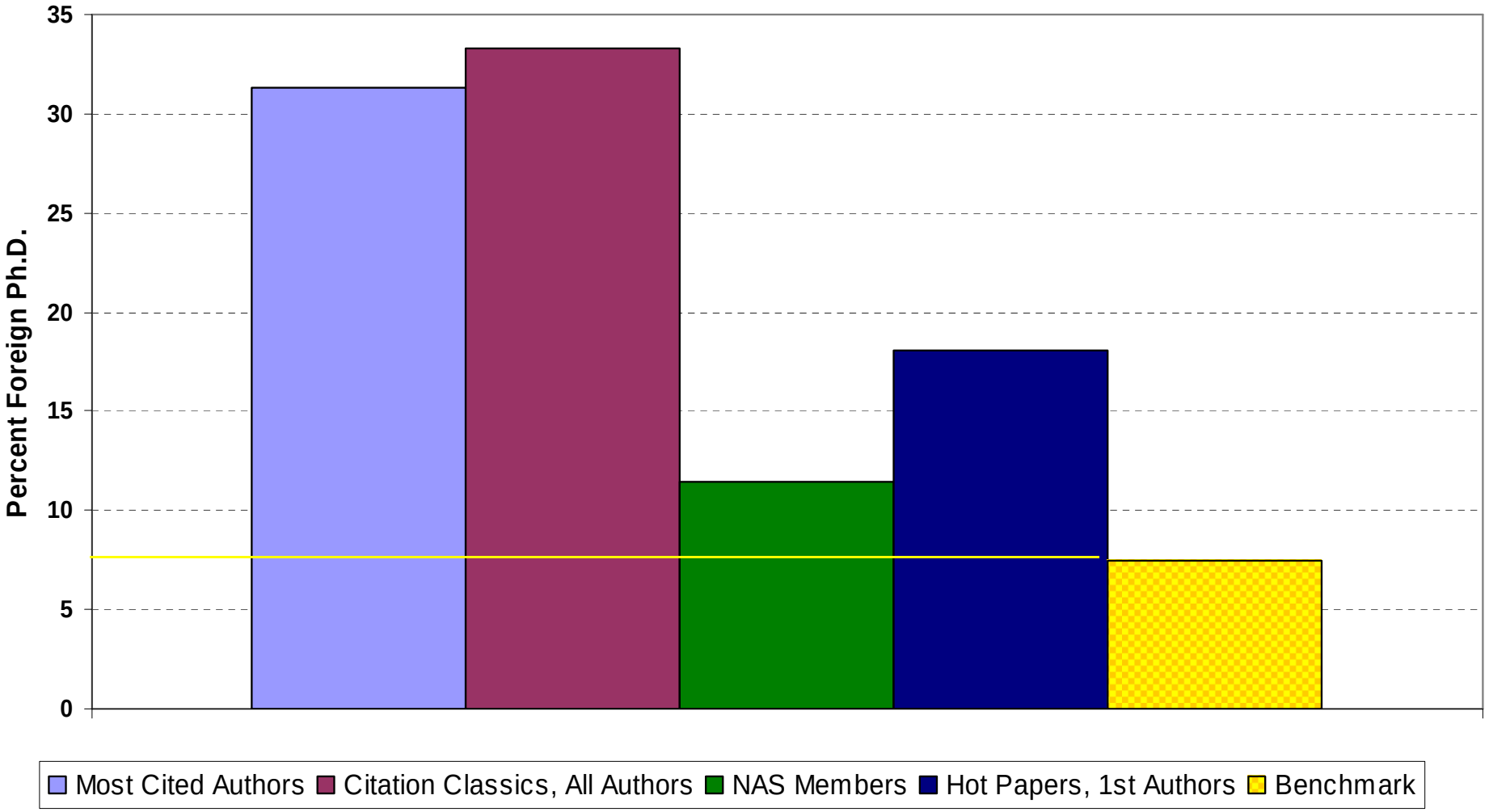
Scientists Making Exceptional Contributions in U.S. Life Sciences



Scientists Making Exceptional Contributions in U.S. Physical Sciences



Scientists Making Exceptional Contributions in U.S. Physical Sciences



Summary

- Foreign born play large role in U.S. science
- Some evidence that foreign-born are disproportionately productive
- Foreign-born who come to U.S. have a high propensity to stay, although stay rates are affected by economic conditions.

Foreign Born in Other Countries

- GlobSci Survey of scientists working in 4 fields (biology, chemistry, earth and environmental, materials) in 16 countries—sample drawn on basis of corresponding author; 40% response
- Joint with colleagues at Politecnico Torino (Giuseppe Scellato) and at Politecnico Milano (Chiara Franzone)
- Preliminary findings—considerable variation by country in presence of foreign born

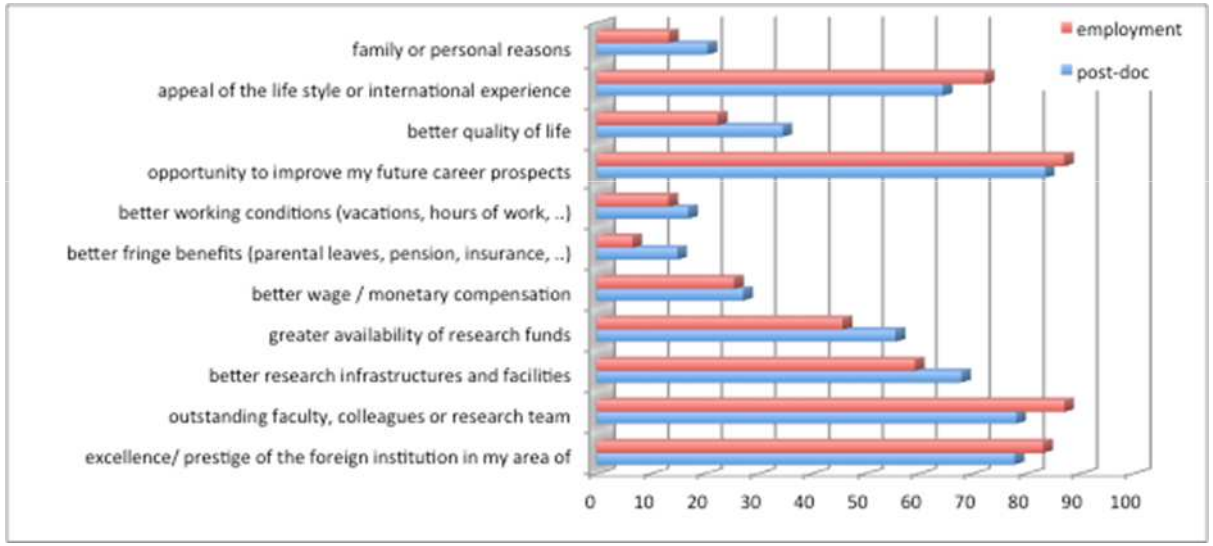
COUNTRY OF WORK OR STUDY IN 2011
Percent outside country at 18

Obs. 17,182

	(number)	%
Australia	(629)	44.5
Belgium	(253)	18.2
Brazil	(702)	7.1
Canada	(902)	46.9
Denmark	(206)	21.8
France	(1320)	17.3

Germany (1187)	**23.2**
India (525)	**0.8**
Italy (1792)	**3**
Japan (1707)	**5**
Netherlands (347)	**27.7**
Spain (1185)	**7.3**
Sweden (314)	**37.6**
Switzerland (330)	**56.7**
UK (1205)	**32.9**
U.S. (4518)	**38.4**

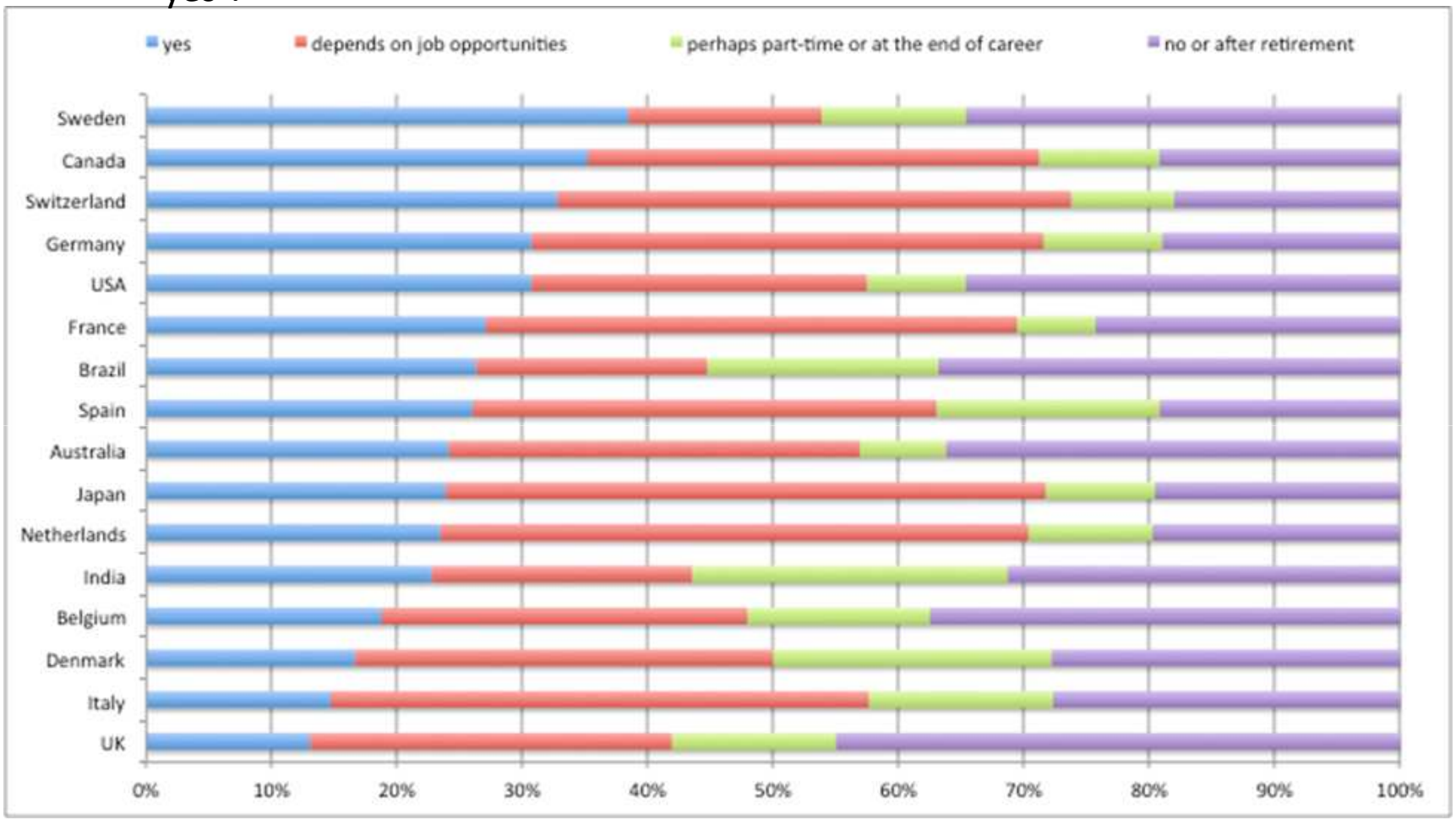
Motivations to Migrate to France for Reasons of Work



Emigration from France

- 59% of scientists living in France at age 18 reported having an international experience, either as a student, postdoc or for work
- 80% of these had returned to France by time of interview
- Personal or family reasons are most important factor leading them to return.
- Considerably more important than professional reasons

“Is it possible that will you return in the future?” by country of residency at age 18 in descending order of percent answering “yes”.



Questions/Comments?

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