Do Return Requirements Increase International Knowledge Diffusion?

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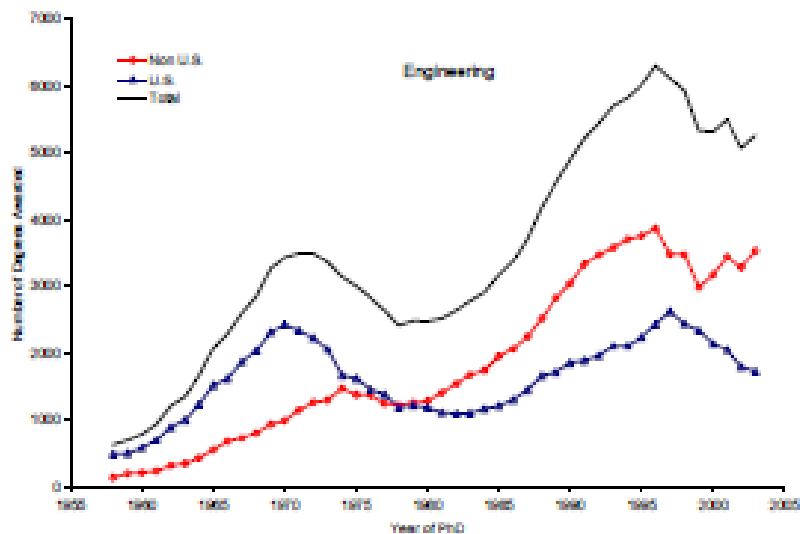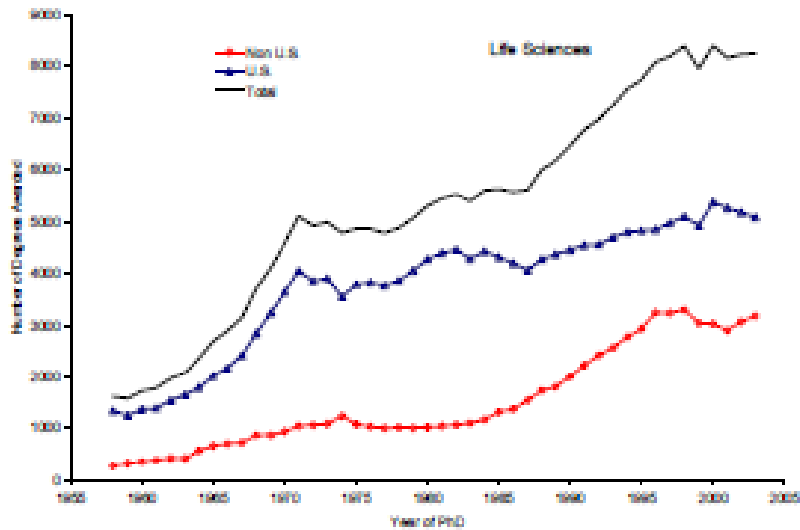
and

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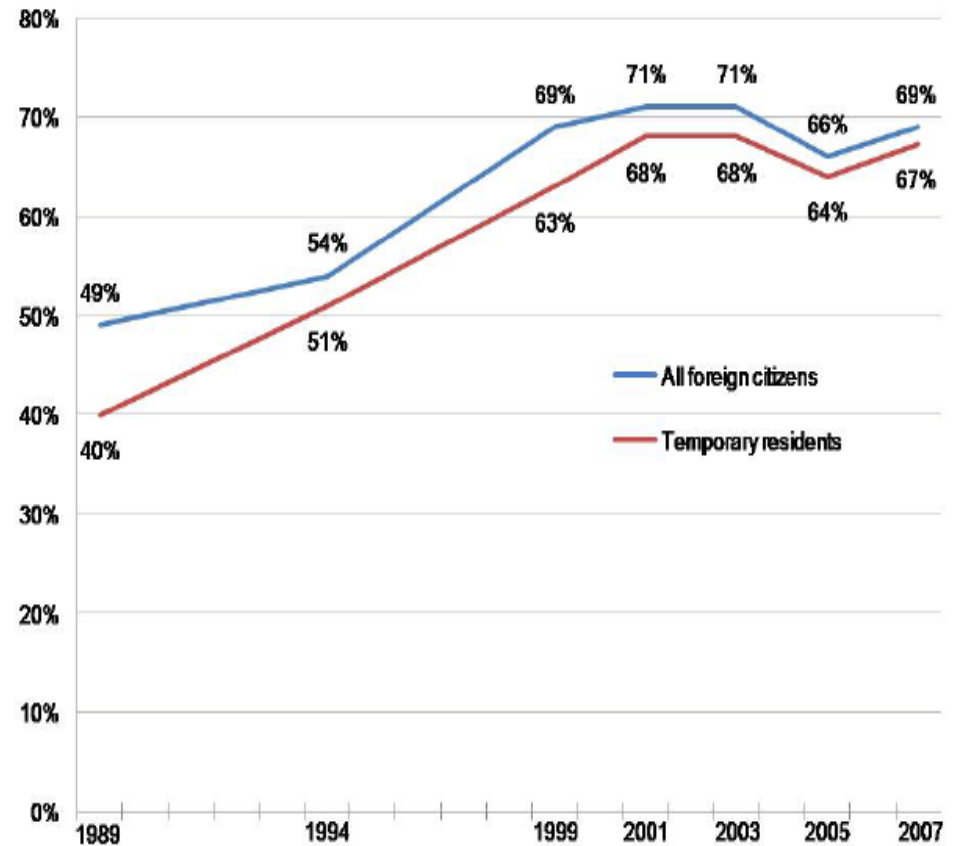WIPO Economics Seminar, 19/11/2013

Ph.D.s awarded by US universities by country of origin

Source: Bound, Turner and Walsh (2009)

Stay rates of foreign Ph.D.s trained in the US

Figure 1. Percentage of Foreign Students Receiving S/E Doctorates Who Were in the United States Two Years After Graduation, 1989-2007

: Oak Ridge Associated Universities.

Source: Finn (2010)

Brain Drain?

- Concern in home countries about emigration of most talented has led to policies to encourage return
    - RAICES repatriation fund in Argentina
    - Initiatives of Chinese Ministry of Education and National Research Council

- The most common policy lever is fellowship funding conditional on return home upon completion of studies

What is the impact of return requirements for S&E PhDs on home countries?

- Positive: Externalities to other scientists in the home country?
- Negative: Loss to country of links to US scientific community?
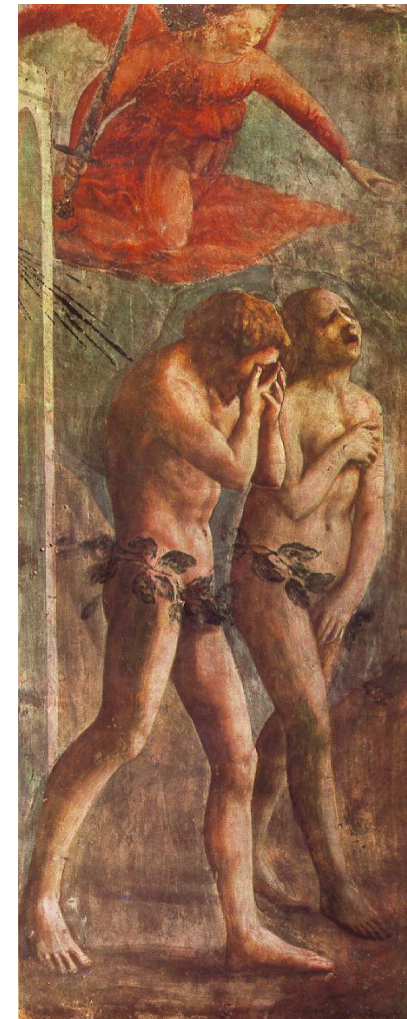
What is the impact of return requirements for S&E PhDs on US science?

- Negative: Losing access to contributions of those who have traditionally been among most productive

- Positive: Building connections to foreign scientists
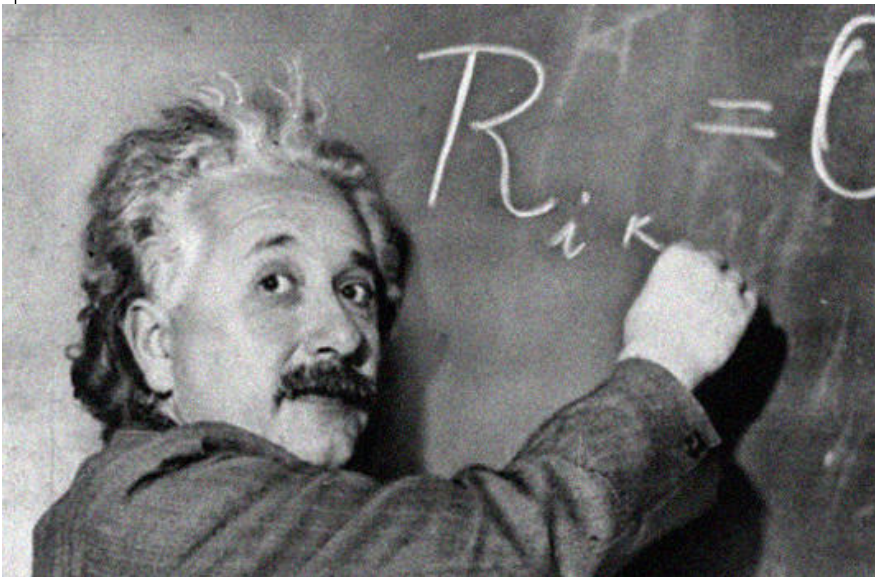
Evidence on negative effects of "Brain Drain"

- Large literature on welfare consequences of migration, particularly from less developed countries (e.g. Bhagwati 1975)
- Proximity is important for science
  - Jaffe et al (1993), Jaffe and Trajtenberg (1999): technological diffusion as measured by patent citations declines with distance
  - Zucker and Darby (2006): the presence of star scientists in a region increases the rate of high-tech firm entry in related fields
  - Agrawal et al (2008): patent citation rates between inventors located in India are 6X higher than between non-co-located Indian inventors
  - Waldinger (2012): substantial long-run negative effects on scientific research in German universities affected by the dismissal of Jewish scientists in WWII

Evidence of positive effects of "Brain Circulation"

- Saxenian (2002):
  - High rates of home-country business activity and information sharing by foreign-born Silicon Valley entrepreneurs
- Agrawal, Cockburn, and McHale (2006):
  - When an inventors move, their patents in the new location are 50% more likely to be cited in their prior location
- Kerr (2008):
  - Common inventor ethnicity increases knowledge sharing as measured by patent citations
- Azoulay, Graff Zivin, and Sampat (2011):
  - Citations to papers by scientists who move to a new location increase dramatically in the new location and do not change in the old location.

What this paper does

- We compare foreigners with US STEM PhDs who are Fulbright Fellows and therefore must return to their home countries to other foreigners with US STEM PhDs with respect to:
  - Whether they are more cited by home country authors (besides themselves) – scientific diffusion from the scientist to the home country.
  - Whether they are equally cited by US authors.
  - Whether they themselves cite home country authors more – scientific diffusion from the home country to scientist.
  - Whether they continue to cite US authors.

Background on Fulbright Return Requirements

- Since its inception in 1946 through 2009, the Fulbright Foreign Student Program has brought more than 128,146 students to U.S. graduate programs.

- Foreign Fulbright Fellows receive J-1 student visas
  - require them to spend at least 2 years in their home countries before applying for a permanent or work visa in the U.S.

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Fulbright Selection Process

- Students submit applications to bi-national Fulbright Commissions and U.S. Embassies in their home countries

- These bodies recommend candidates to the J. William Fulbright Foreign Scholarship Board (FSB). The FSB makes the final selections for candidates.

- Some countries require students to obtain admission to a US university prior to awarding the fellowship, but most grant the fellowship first and then students are placed at US universities.

- Most of the universities in our sample are large public universities. The median program rank is 29.

Creating our database

- We collected a data set of 249 foreign students who had Fulbright fellowships in the mid-1990's for Ph.D. study in science & engineering

- We match each Fulbright with another international student:
  - In the same department in the same university as the Fulbright
  - Who had the same advisor (if possible) and who
  - Received their PhD in the same year if possible, or within 3 yrs.

- We identify these 498 students' locations, publications and citations through 2007.

Data Sources and Data Set

- *Directory of Foreign Fulbright Fellows (1993-1996)*

- *Proquest Dissertations and Theses*
  - Fulbright's advisor and year of Ph.D.; used to identify control students

- Googling
  - Information on Post-Ph.D. locations is obtained from various sources (faculty web pages, C.V.'s, LinkedIn, publications, patents, company announcements, etc.)
  - Keep pairs only if both members can be found

- *ISI Web of Science*
  - Data on publications, citations, institutional affiliations

Sources of Location Information
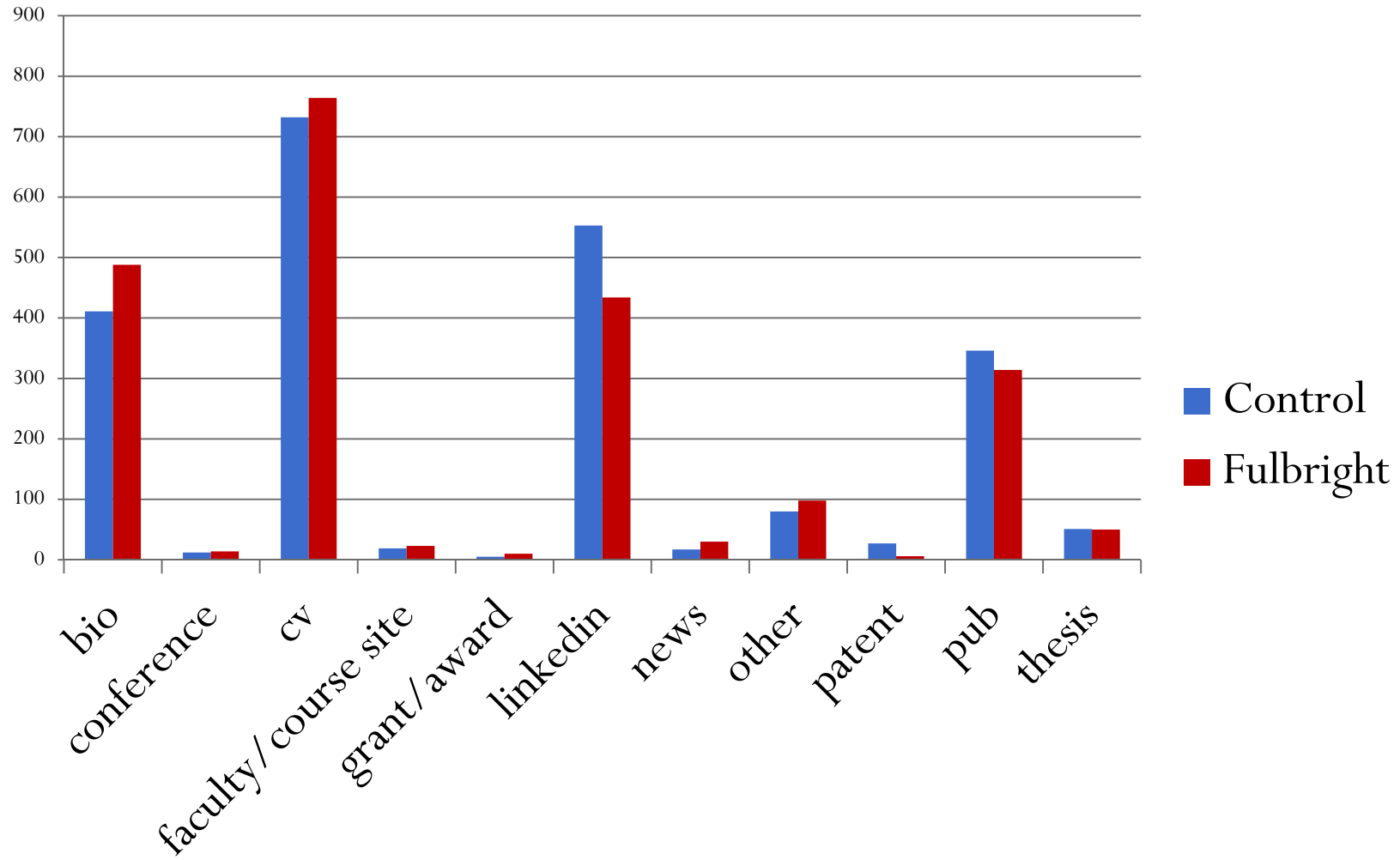
Regions of Origin

	Control	Fulbright	Total
Asia	82	7	89
Europe	96	88	184
Latin Amer	39	120	159
ME/Africa	32	34	66
Total	249	249	498

Year Ph.D. granted
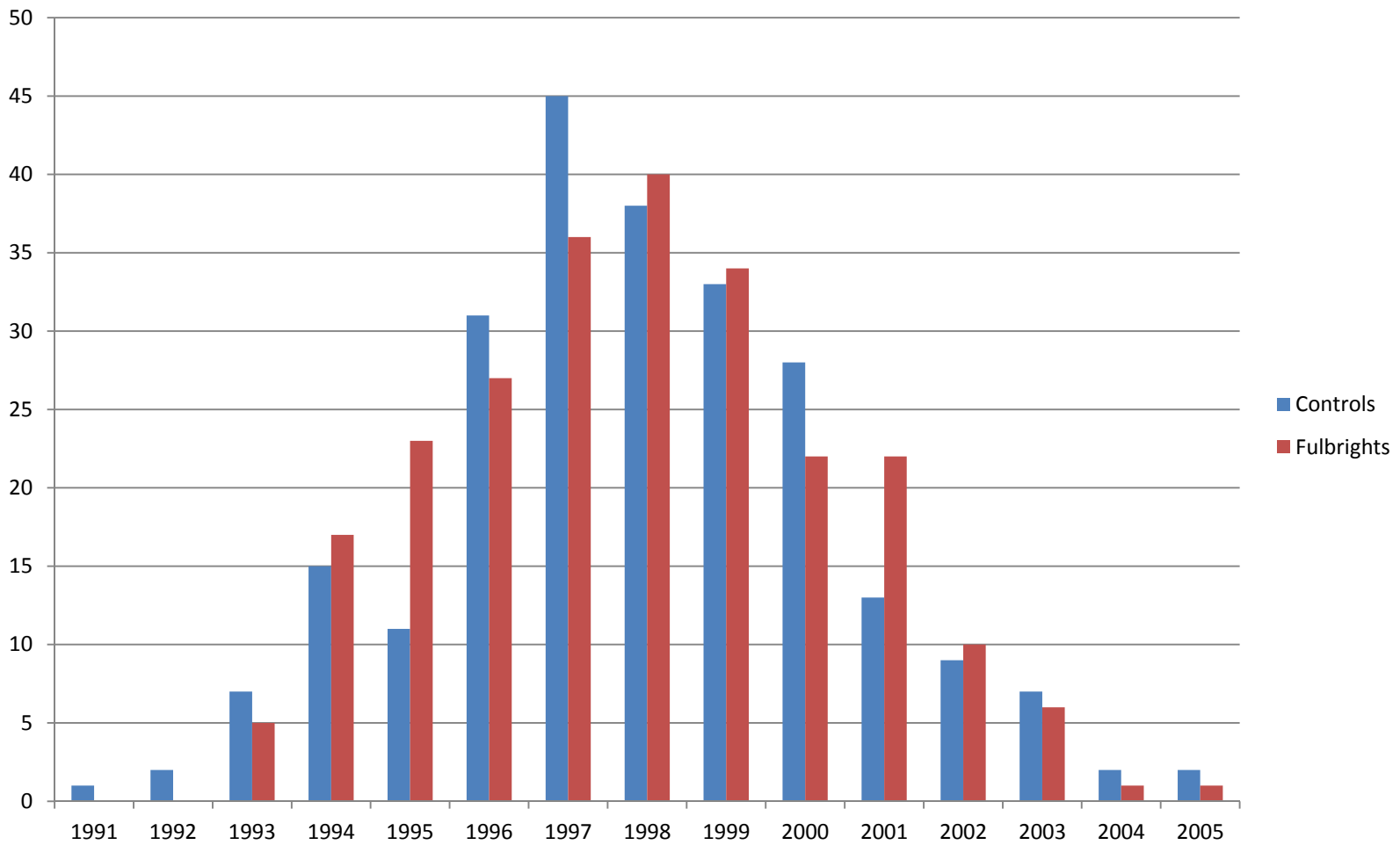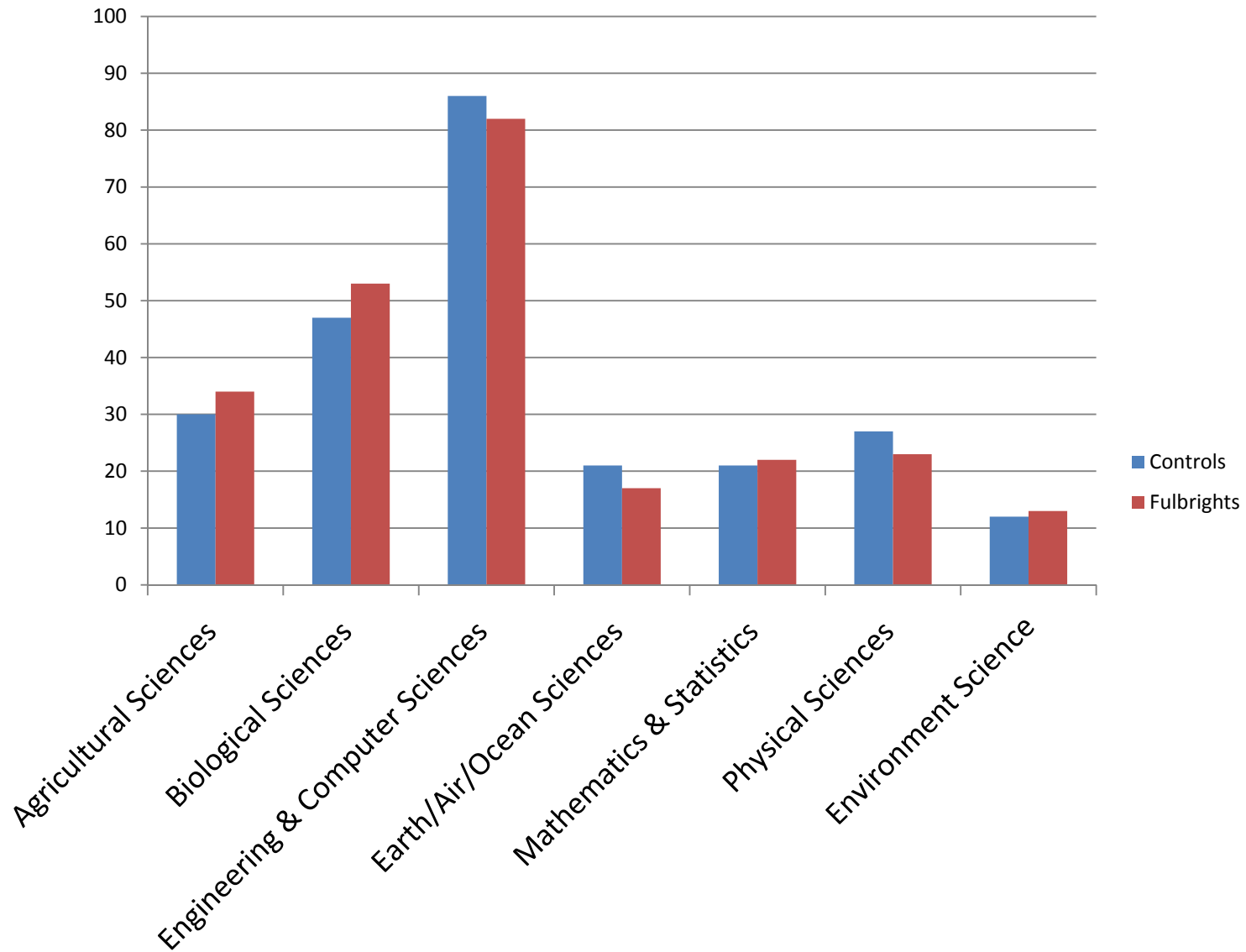
Quality bias?

- Fulbrights could be positively selected…

- …or negatively selected

- We'll talk about this in the context of the results

Evidence of impact of return requirements on:

1. Productivity

2. Collaboration

3. Citation

Evidence of impact of return requirements on:

1. Productivity

2. Collaboration

3. Knowledge diffusion

Productivity regressions

- Poisson regressions with a variety of independent variables on a Fulbright dummy
- Control variables
  - Field
  - Year of PhD (dummies)
  - Institution rank
  - Gender
  - Home country GDP per cap
    - and GDP interacted with Fulbright
  - Pre-graduation research output (total, first-authored, and first/last authored high-impact publications)

Fulbright-control productivity gap, by income of home country

Home country GDPpc	(1) Total Publications	(2) First-authored Publications	(3) Last-authored Publications	(4) High-Impact Publications
25th pctile	-0.502***	-0.504***	-0.817***	-0.535*
50th pctile	-0.343***	-0.282**	-0.587***	-0.449***
75th pctile	-0.169	-0.016	-0.177	-0.363
90th pctile	-0.053	0.172	0.207	-0.310

Evidence of impact of return requirements on:

1. Productivity

2. Collaboration

3. Knowledge diffusion

Impact on science produced in specific locations

- # articles with at least one home-country author
  - Including or excluding author's current location

- # articles with at least one US author
  - Including or excluding author's current location

- # articles with a home-country author AND a US author (or third-country author)

Impact on home country's science

Fulbright-control differential in:	w. Pregrad controls
Total pubs with any home country author	1.197**
Total pubs with any home country author excl self	1.048**
Total pubs with any US author	-0.366**
Total pubs with any US author excl self	-0.254*
Total pubs with authors in home AND US	0.652**
Total pubs with authors in home AND 3rd coun.	1.467**

Fulbright increases home country – US collaboration…

Impact on US science

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Total pubs with authors in home AND 3rd coun.	1.467**

Fulbrights have lower rates of US science production relative to foreign students without return requirement.

Impact on home country/US collaboration

Fulbright-control differential in:	w. Pregrad controls
Total pubs with any home country author	1.197**
Total pubs with any home country author excl self	1.048**
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Total pubs with authors in home AND 3rd coun.	1.467**

Fulbright increases home country – US collaboration…
…and collaboration with third countries as well

Findings on productivity and collaboration

- Fulbrights from low-income countries have:
  - **fewer articles in total** (particularly last-authored & in high-impact journals).

- Fulbrights from rich countries have:
  - total publications similar to controls.

- Fulbrights from all countries have:
  - **more** articles with **US–home country collaboration.**

Evidence of impact of return requirements on:

1. Productivity

2. Collaboration

3. Knowledge diffusion

Measuring knowledge diffusion

- Two types of article citations:

  1. Forward cites: citations *to* the scientist's articles

  2. Backward cites: citations made *by* the scientist's articles

Dependent variables: (forward) citations

- We count the number of citations to scientist i's articles published in year t found in publications from home country/US in year T (through 2007)
  - Country = reprint author's address
  - Web of Science journals
    - No evidence of undercounting of foreign pubs in CVs
  - Self-citations dropped
  - Poisson model, standard errors clustered by scientist

Dependent variables: backward citations

- We also count the number of citations from scientist i's articles published in year t to publications by home country/US corresponding authors.

Key RHS variables

- Fulbright dummy
- Fulbright X low-income home country
  - i.e. below 75th percentile of GDP per capita
- Fulbright X high-income home country
- Proxies for high/low home country science base interacted with Fulbright
  - Articles per capita in field published in home country
  - Citations per article in field published in home country
- Sometimes: location dummy for home country, third country

Key RHS variables continued

- Expect forward citations to be proportional to:

  maximum potential citations $=$ $N_{it} * N_{FT}$

  N_{FT} = potentially citing papers in field-country F in year T

  N_{it} = potentially cited papers by author i in year t

  (Jaffe-Trajtenberg 1999, Adams-Clemmons 2006)

- Therefore we add these two RHS variables in logs:
- Total Articles published in the field in the home country in year T (*Scimago* country indicators)
- Articles published by the scientist in year t (sometimes)
  - Include dummy for scientists with no pubs in year t

Other control variables

- Field dummies

- PhD Program rank in 1995 (National Research Council)

- Gender

- Fixed effects for:
  - Year of PhD graduation
  - Citing year
  - Years since article publication (forward citations)

| Variable	Mean	Std. Dev.	Min	Max
Number of citations in year T to articles published in year t from home country	0.053	0.370	0	11
Number of citations in year T to articles published in year t from USA	0.741	3.709	0	151
Number if home-country citations excluding regional journals	0.052	0.368	0	11
Number of US citations excluding regional journals	0.739	3.706	0	151
Number if home-country citations excluding collaborations with main advisor	0.039	0.330	0	11
Number of US citations excluding collaborations with main advisor	0.538	3.597	0	151
Number of backward citations to USA in year t	6.970	19.506	0	411
Number of backward citations to home country in year t	0.411	2.725	0	74
Number of backward citations to home country excluding collaborations with main advisor	0.371	2.691	0	74
Number of backward citations to USA excluding collaborations with main advisor	4.696	17.801	0	411
Fulbright dummy	0.498	0.500	0	1
Fulbright from a country >75th pctile GDP per capita	0.195	0.396	0	1
Fulbright from a country <75th pctile GDP per capita	0.303	0.460	0	1
Scientist from a country <75th pctile GDP per capita	0.602	0.490	0	1
Publications by scientist i in year t	0.800	1.386	0	8
ln Number of publications in scientist i's field in home country in citing year	6.272	1.870	0	10.801
Share of scientist's publications in high-impact journals	0.160	0.341	0	1
Citations per publication in scientist I's home country in 2000	10.504	6.899	0	154.75
Pre-graduation citations to home country	1.307	14.044	0	294

Fwd Home country citations

	(1)	(2)	(3)	(4)	(5)
Fulbright	0.0193 (0.327)	0.815** (0.388)	0.756*** (0.247)		
Fulbright from high-income home country				0.658* (0.390)	0.445 (0.293)
Fulbright from low-income home country				0.927** (0.417)	1.174*** (0.352)
Low-income home country				-1.147*** (0.297)	-0.917*** (0.305)
In Publications in home country/field in citing year		0.778*** (0.145)	0.472*** (0.103)	0.680*** (0.112)	0.431*** (0.0899)
In Publications by scientist in cited year			1.068*** (0.164)		0.958*** (0.171)
1 if female	-1.038*** (0.283)	-1.293*** (0.301)	-0.676*** (0.188)	-1.409*** (0.284)	-1.038*** (0.283)
	-0.178	-0.230**	-0.190**	-0.163*	-0.178

222% more citations

Fwd Home country citations cont.

	(6)	(7)
Fulbright from country >75th pc articles per capita in field	0.409 (0.293)	
Fulbright from country <75th pc articles per capita in field	1.334*** (0.342)	
Home country <75th pc articles per capita in field	-1.085*** (0.286)	
Fulbright from country >75th pc cites per article in field		0.360 (0.315)
Fulbright from country <75th pc cites per article in field		1.030*** (0.299)
Home country <75th pc cites per article in field		-0.810*** (0.266)

Fulbright-Control difference in citations from home country, by years since PhD
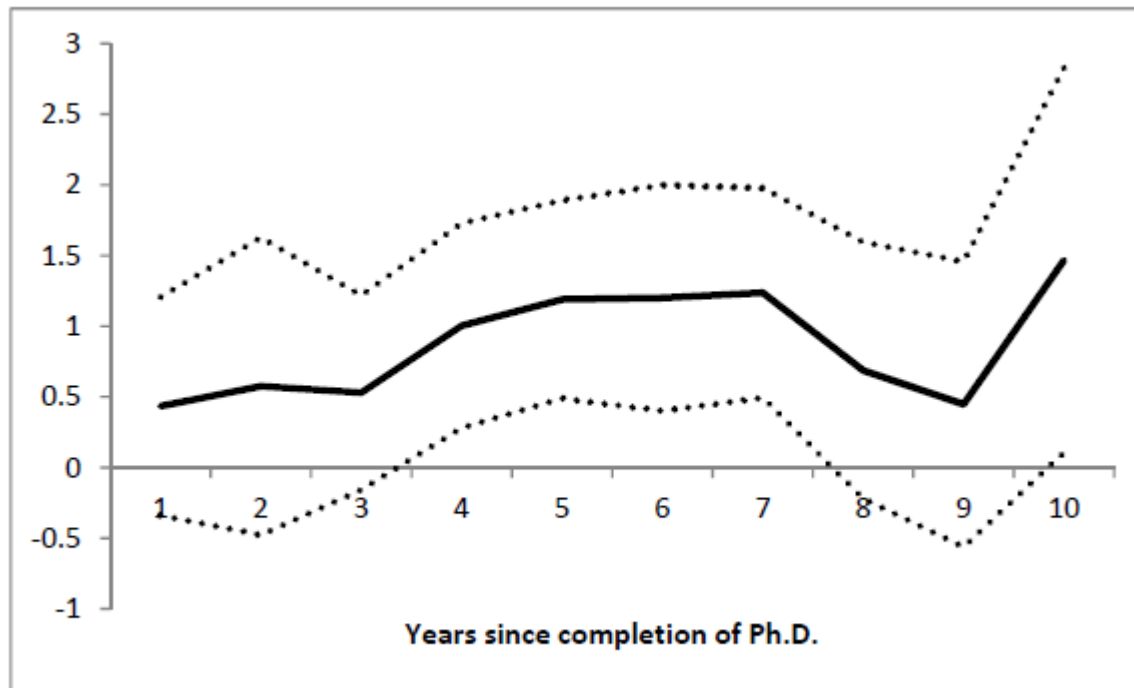
Years since completion of Ph.D.

Controlling for scientist & home-country articles, citation lag, year of Ph.D., field, gender, and Ph.D. program rank.
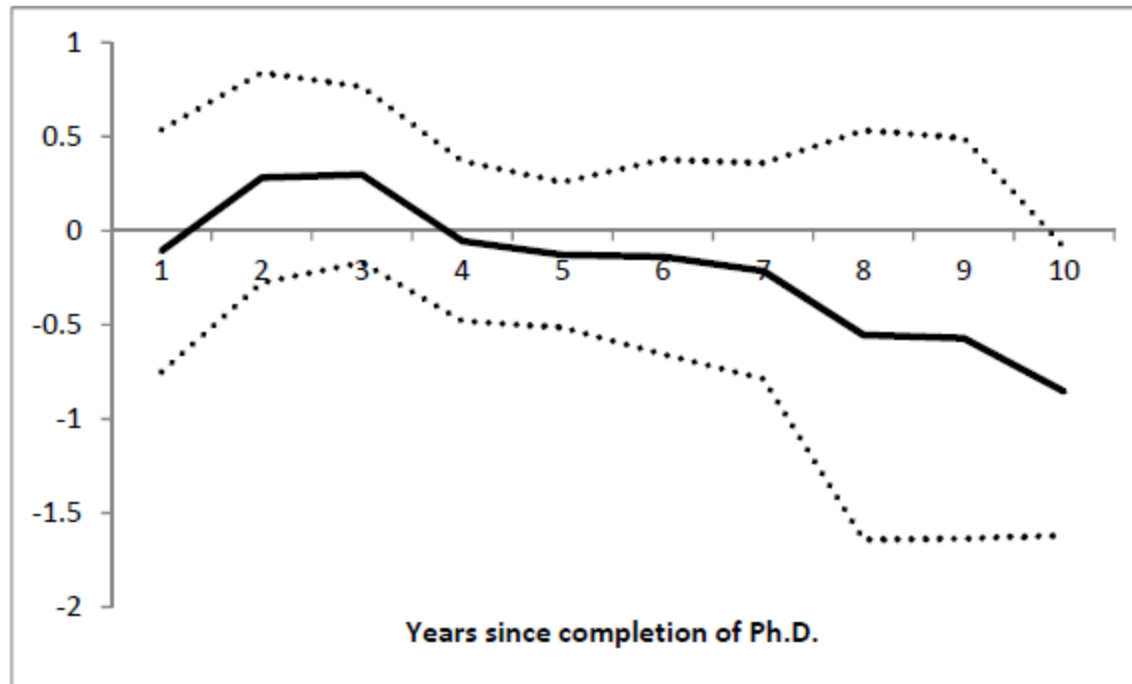
Fwd US Citations

	(1)	(2)	(3)	(4)	
Fulbright	-0.133 (0.284)	-0.152 (0.269)	-0.0426 (0.137)		
Fulbright from high-income home country				0.361 (0.338)	0.176)
Fulbright from low-income home country				-0.810*** (0.271)	-0.440** (0.223)
Low-income home country				-0.469* (0.275)	-0.102 (0.216)
ln US publications in field in citing year		0.502* (0.272)	0.196 (0.124)	0.481** (0.229)	0.172 (0.124)
ln Publications by scientist in cited year			1.406*** (0.147)		1.304*** (0.127)
Female	-0.704** (0.330)	-0.649** (0.301)	-0.123 (0.192)	-0.778*** (0.300)	-0.142 (0.179)
ln Rank of PhD program	-0.263* (0.139)	-0.256** (0.125)	-0.240*** (0.0674)	-0.134 (0.0997)	-0.199*** (0.0623)

36% fewer citations

Fwd Home country citations cont.

	(6)	(7)
Fulbright from country >75th pc articles per capita in field	0.178 (0.173)	
Fulbright from country <75th pc articles per capita in field	-0.412* (0.221)	
Home country <75th pc articles per capita in field	-0.112 (0.226)	
Fulbright from country >75th pc cites per article in field		0.205 (0.185)
Fulbright from country <75th pc cites per article in field		-0.306 (0.203)
Home country <75th pc cites per article in field		-0.0422 (0.197)

Fulbright-Control difference in citations from US, by years since PhD

Years since completion of Ph.D.

Controlling for scientist & home-country articles, citation lag, year of Ph.D., field, gender, and Ph.D. program rank.

Robustness checks:
Is the research of Fulbrights inherently more relevant to scientists at home?

- National Fulbright Commissions may select applicants who express desire to contribute to the development of knowledge in the home country

- In graduate school, Fulbrights may choose research fields in which the home country has a relative strength

For forward home citations, low-income Fulbright effect is robust

- To controlling for field via:
  - Sector of employment
  - Narrow field dummies
  - Pre-grad citations to home country
  - Dropping regional journals
  - Dropping Agricultural/Environmental scientists

- To controlling for total impact via:
  - Share of scientist's pubs in high-impact journals
  - Forward citations from non-home countries
  - Dropping obs > 90th pctile total citations

Scientist's backward citations to home country

	(1)	(2)	(3)	(4)
Fulbright	0.329 (0.384)	1.173** (0.459)	1.228*** (0.267)	
Fulbright from low-income home country				1.027*** (0.310)
Fulbright from high income home country				1.334*** (0.394)
Low-income home country				-0.573 (0.381)
ln Publications by scientist in cited year			1.255*** (0.120)	1.190*** (0.132)
ln Publications in home country/field in citing year		0.798*** (0.202)	0.429*** (0.0922)	0.369*** (0.0794)
Female	-0.826*** (0.320)	-1.059*** (0.360)	-0.482** (0.244)	-0.498** (0.228)
ln Rank of PhD program	0.00974 (0.202)	-0.0727 (0.119)	-0.0792 (0.0942)	-0.0658 (0.101)

Fulbright-Control difference in citations to home country, by years since PhD
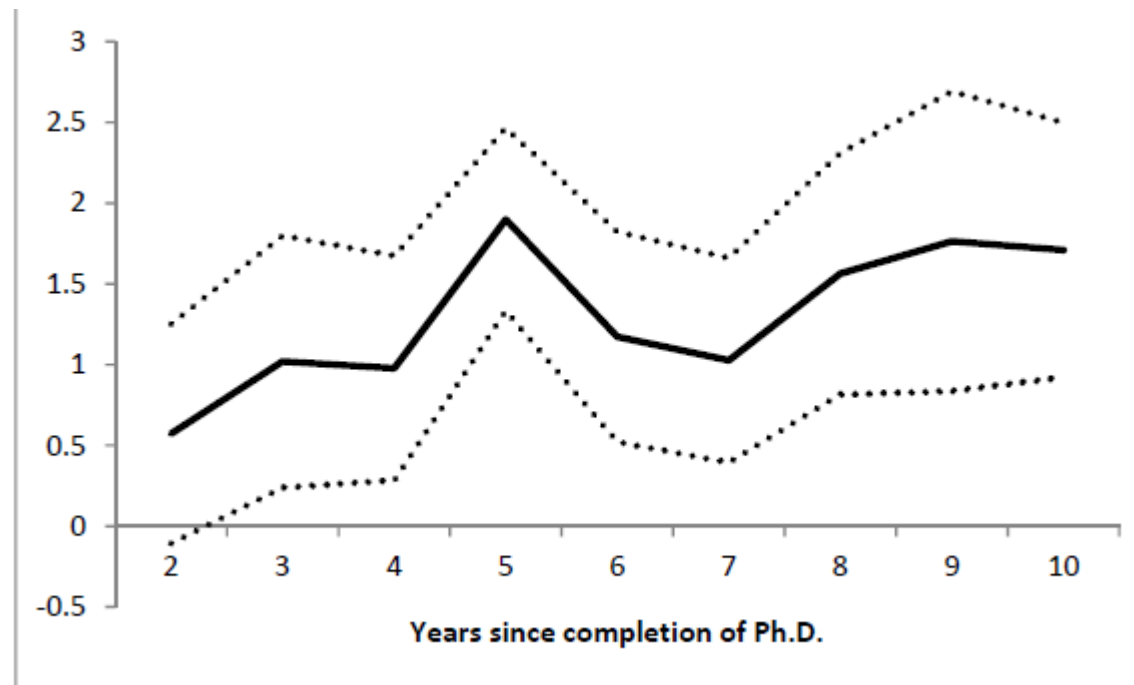
Controlling for scientist & home-country articles, citation lag,
year of Ph.D., field, gender, and Ph.D. program rank.

Scientist's backward citations to the US

	(1)	(2)	(3)	(4)
Fulbright	-0.233	-0.0666	-0.0735	
	(0.166)	(0.121)	(0.0719)	
Fulbright from high-income home country				-0.0224
				(0.110)
Fulbright from low-income home country				-0.132
				(0.102)
Low-income home country				0.00766
				(0.108)
ln Publications by scientist in cited year			1.216***	1.207***
			(0.0621)	(0.0605)
Ln Articles published in field in US in citing year		0.0276	-0.113*	-0.114*
		(0.136)	(0.0675)	(0.0679)
1 if female	-0.329	-0.256	0.0230	0.0171
	(0.203)	(0.159)	(0.825)	(0.105)
ln Rank of PhD program	-0.0538	0.0433	-0.0750**	-0.0678*
	-0.329	-0.256	0.0230	0.0171

Proximity matters for citations for both high and low income countries

	(1)	(2)	(3)	(4)
Dependent variable	Fwd cites from home	Fwd cites from USA	Backward citations to home	Backward citations to USA
Fulbright	0.327*	0.0532	0.804***	0.0132
	(0.188)	(0.127)	(0.212)	(0.0723)
Located in High-income Home country	0.735***	-0.0740	0.887***	-0.178
	(0.224)	(0.194)	(0.227)	(0.137)
Located in Low-income Home country	1.316***	-0.587***	1.304***	-0.350***
	(0.304)	(0.195)	(0.413)	(0.103)
Low-income Home country	-0.806***	-0.256	-0.641**	0.00709
	(0.261)	(0.182)	(0.312)	(0.0929)
Located in home region	0.412	-0.354	-0.512	-0.436***
	(0.377)	(0.300)	(0.394)	(0.143)
Located outside US in non-home region	-0.552	-1.064***	-0.565	-0.253
	(0.424)	(0.284)	(0.420)	(0.192)

However, the effect of Fulbright on return propensity is bigger for poor countries

Dependent variable	Located at home
Fulbright from high-income home country	0.268***
	(0.063)
Fulbright from low-income home country	0.462***
	(0.047)
Low-income home country	-0.0948
	(0.0598)
ln Publications by scientist in cited year	-0.0749**
	(0.0326)
ln citations per publication in home country in field	0.00736
	(0.0115)
ln publications in scientist's field in home country in citing year	-0.00182
	(0.00246)

Conclusion: Should governments create programs with return requirements?

For low-income, low-science countries:

- Scientific articles by Fulbrights are cited more frequently in their home countries than articles by controls,
  - *because* doctorates spend more time in the home country.

Conclusion: Should governments create programs with return requirements?

For high-income, high-science countries:

- No significant difference between Fulbrights and controls in citations from high income countries
  - because while location in home country is still important, it is less important for rich countries AND Fulbrights' location is less affected by being a Fulbright.

$\longrightarrow$ Return requirements may not be necessary to increase domestic access to knowledge

For all home countries:

- return requirements redirect research agendas towards the home country

Conclusion: Should governments create programs with return requirements?

- From the US perspective:
  - Return to high-income home countries does not affect diffusion to/from US scientists

  - Returning researchers appear to maintain their links with the US despite their absence

Conclusion: Should governments create programs with return requirements?

- From the global perspective:
  - Return requirements for rich-country scientists associated with no difference in productivity
  - Return requirements for poor-country scientists associated with large decline in research output, particularly in articles reflecting roles as "lab head" or in prestigious journals
  - However, observed flows of human capital to back lower-income countries surely reflect unmeasured benefits…like improved access to scientific knowledge

Thank you! Merci! Danke Schön!

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