Will the United States Keep the Best and the Brightest? Career and Location Preferences of Foreign STEM PhDs

Ina Ganguli
University of Massachusetts Amherst
Patrick Gaulé
University of Bath & CERGE-EI

AEA Meetings
"Foreign STEM Students & Immigration Policy"
January 6, 2018

Outline

1. **Motivation and overview**
2. Survey of Chemistry PhD students
3. Comparing the career preferences of foreign and domestic students
4. Comparing the location preferences of foreign and domestic students
5. Revealed preferences ranking of U.S. and foreign universities for postdoc

Motivation: Foreign-born PhDs in the U.S.

- Key to U.S. leadership in STEM fields is attract and *retain* top tier talent from other countries
- Represent half or more of PhD students; are more productive during the PhD than natives (Gaule & Piacentini, 2013, Stuen, Mobarak & Maskus, 2012).
- Generally, foreign born make disproportionate contributions to U.S. science and innovation (Levin & Stephan 1999, Hunt & Gauthier-Loiselle, 2010)

Source: https://www.politico.com/magazine/story/2017/10/01/donad-trump-making-canada-great-again-215651

Motivation: Foreign-born students in the U.S.

- Growing evidence on location and career choices after students have already gotten jobs, reflecting both supply- and demand-side factors
  - From SED: Foreign-born intending to stay in the US are positively selected (Grogger and Hanson, 2015)
  - Foreign-born PhDs are more likely than the US-born to take a postdoctoral positions (Stephan and Ma, 2005)
  - From NSCG: Restrictive visa policies appear to lead students to "settle for academia" (Amuedo-Dorantes and Furtado, 2018)

Is the U.S. retaining the `best' foreign-born PhDs?

- *Do foreign and U.S students have different career and location preferences? Is there evidence of selection?*
- Foreign students are making choices both about *sector of employment* (industry vs. academia) and *location* (U.S. or abroad)
- To measure worker preferences, need to do so prior to when they obtain a job

Is the U.S. retaining the `best' foreign-born PhDs?

- Measure of preferences are important for policymakers:
  - Expanding visa policies to attract high-skilled are only effective if students want to stay in the US
  - More restrictive policies can lead top talent to prefer highly ranked institutions or top firms abroad

Our study: Preferences of U.S. and foreign PhDs

- We conducted a survey of 1,605 current PhD students in a major STEM field (Chemistry) in 2017
- Measure preferences of foreign and US graduate students for:
  - Academic (post-doc) vs. Industry jobs
  - Post-docs at institutions in the US vs. abroad
- Employ hypothetical choice methods (Zeithammer and Kellogg, 2013; Wiswall and Zafar, 2017)
- Revealed preference ranking of top US and foreign institutions as a postdoc location (Avery, Glickman, Hoxby and Metrick, 2012)

Preview of results

Using unique survey data and methods to measure preferences, we show:

1. Foreign students are more likely to prefer research careers (post-docs)
2. Far from being a 'flight risk', foreign students have a stronger preference for US locations for a comparable job (post-doc) even after controlling for ability and career preferences
3. A revealed preference ranking of institutions in the US and abroad differs for foreign and U.S. students; U.S. Universities are perceived as more desirable for a postdoc than a bibliometrics-based ranking suggests

Outline

1. Motivation and overview
2. **Survey of Chemistry PhD students**
3. Comparing the career preferences of foreign and domestic students
4. Comparing the location preferences of foreign and domestic students
5. Revealed preferences ranking of U.S. and foreign universities for postdoc

2017 Survey of Chemistry PhD students

- Survey conducted in Fall 2017 of 1,605 current Chemistry doctoral students enrolled in a U.S. institution
- The sampling frame is drawn from the graduate student directories and lab websites of the top 50 U.S. Chemistry departments
- Sample represents approximately 30-40% of enrolled Chemistry students (2013, NSF)

2017 Survey of Chemistry PhD students

- We gather data on:
  - Demographics
  - Career and location preferences
  - Self-reported ability (linking now to publications)
  - Measures of confidence, locus of control

	US Student	Foreign Student	Difference
Female	0.465	0.379	0.086**
Married	0.161	0.193	-0.032
Enrolled 2015	0.209	0.205	0.004
Enrolled 2014	0.187	0.210	-0.023
Enrolled 2013	0.187	0.131	0.056**
Enrolled 2012	0.101	0.082	0.019
Enrolled 2011	0.022	0.017	0.004
Field of Study			
Analytical	0.119	0.087	0.032
Biological/Biochemistry	0.168	0.193	-0.025
Inorganic Chemistry	0.172	0.146	0.025
Organic Chemistry	0.180	0.173	0.007
Physical	0.154	0.146	0.008
Polymer	0.046	0.047	-0.001
Theoretical/Computational	0.061	0.094	-0.033*
Other	0.101	0.114	-0.013
Country of Undergrad			
Canada		0.050	
China		0.302	
India		0.134	
Observations	1201	404	

Outline

1. Motivation and overview
2. Survey of Chemistry PhD students
3. **Comparing the career preferences of foreign and domestic students**
4. Comparing the location preferences of foreign and domestic students
5. Revealed preferences ranking of U.S. and foreign universities for postdoc

Methods: Career Preferences

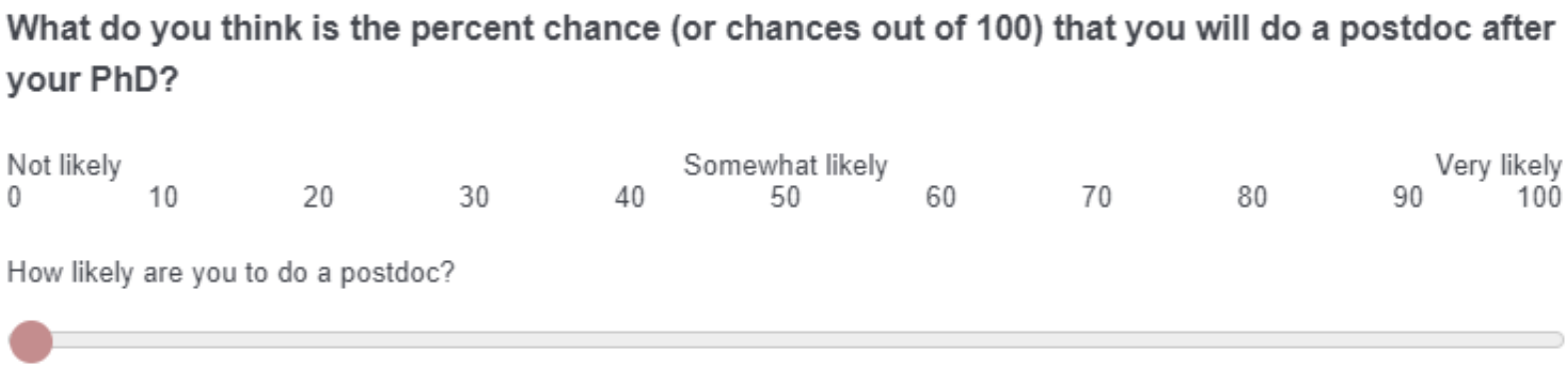
- Estimate differences in the preferences for the foreign-born vs. natives – even when comparing very similar students (same PhD program, area of specialization, self-reported ability)
- We measure preferences/aspirations towards an academic or industry career in different ways

Measuring careers preferences (1)

Putting job availability aside, how attractive do you personally find each of the following careers?

	Not at all attractive (1)	Mostly not attractive (2)	Neutral (3)	Mostly attractive (4)	Very attractive (5)
Academic faculty with an emphasis on research	O	O	O	O	O
Academic faculty with an emphasis on teaching	O	O	O	O	O
Government research and development position	O	O	O	O	O
Government (other)	O	O	O	O	O
Industry position with an emphasis on research and development	O	O	O	O	O
Industry (other)	O	O	O	O	O

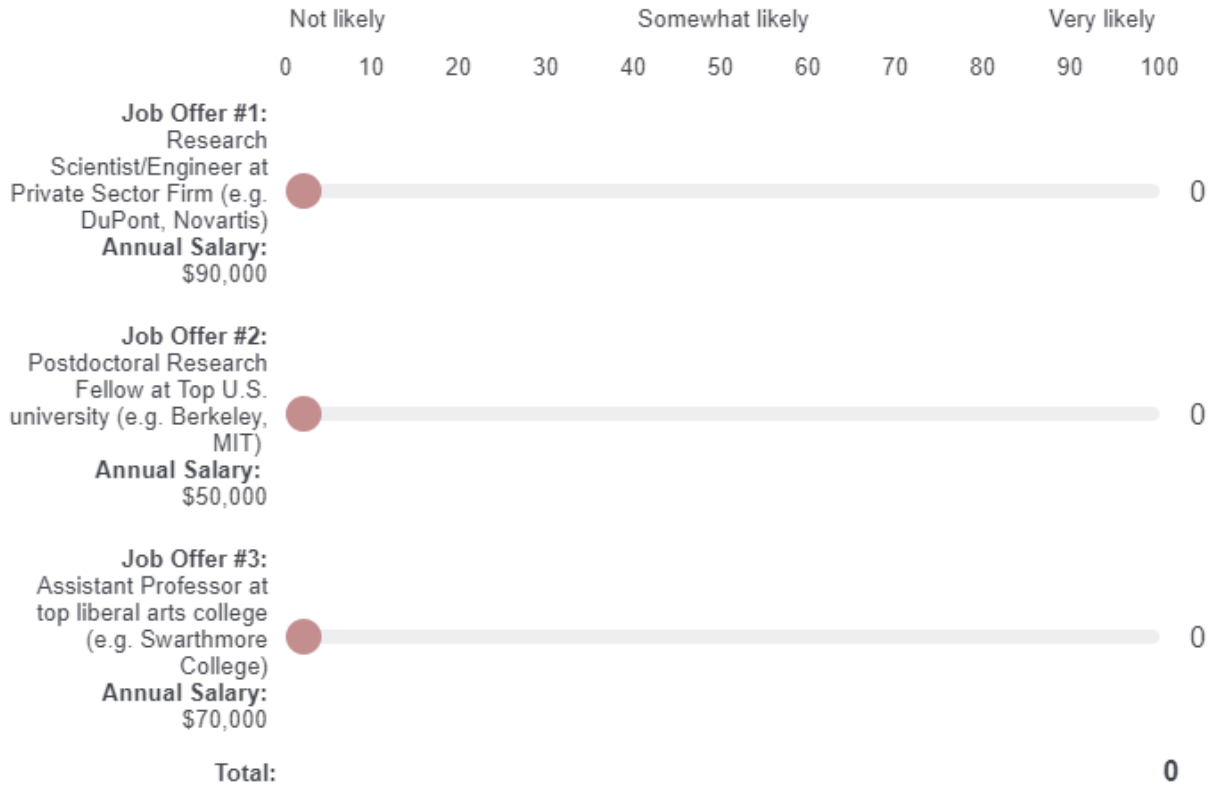
Measuring careers preferences (2)



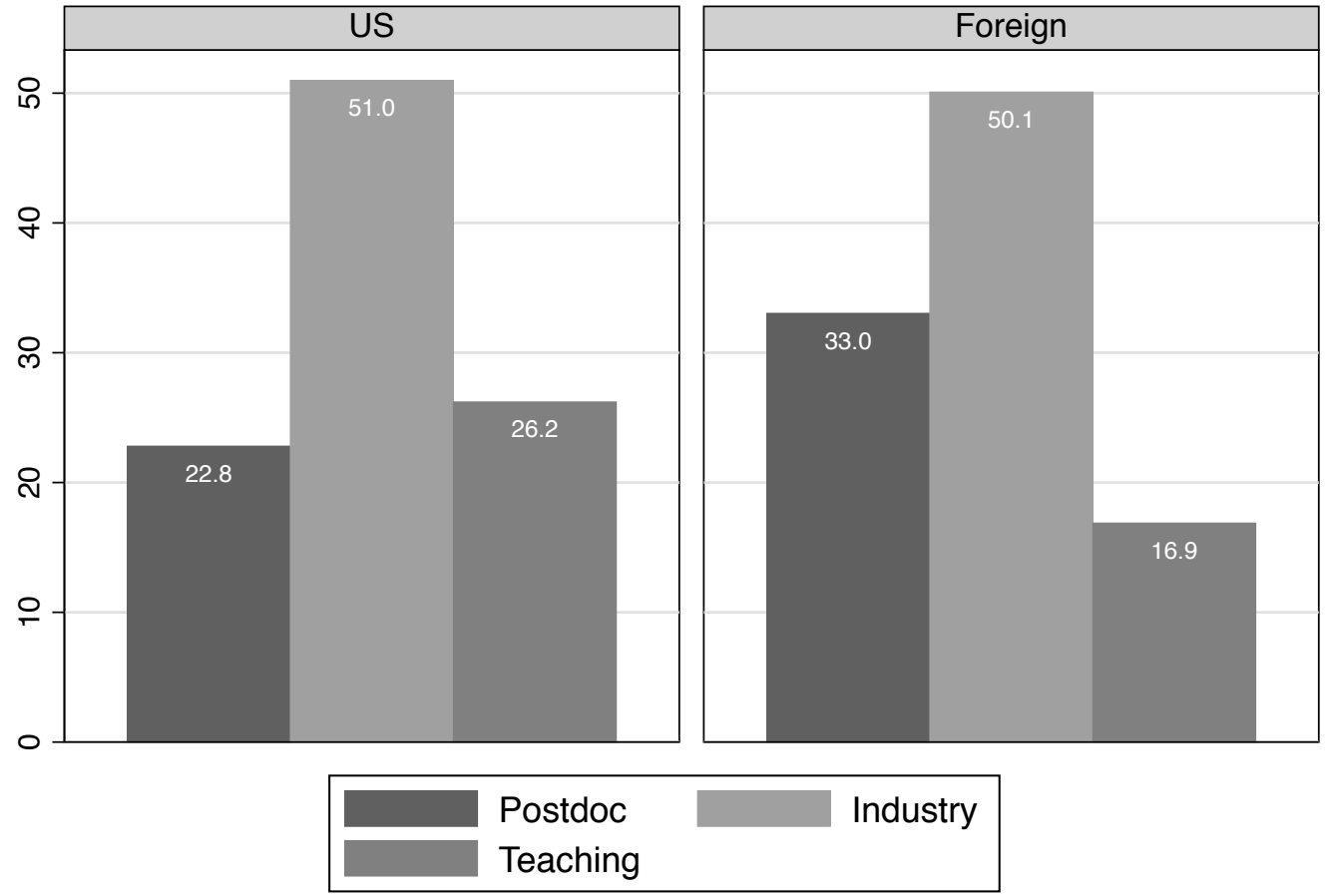
Note: in Chemistry, a postdoc is a necessary step in an academic career, though not all postdocs stay in academia

Measuring careers preferences (3)

First, suppose you have the following job offers and you need to choose between them. Please rate how likely you are to accept one of them rather than the other. For each job offer, choose the percent chance (out of 100) of choosing each one. The total chances given to each offer should add up to 100.



Results: foreign students more likely to choose post-doc than U.S.; similar industry preferences



Results: foreign students are more interested in academic careers

	(1) Attractiveness of TT faculty job (1-5 Likert)	(2) Likelihood of doing a postdoc (out of 100)	(3) Chances of choosing postdoc option (among 3 choices)
Foreign student	0.829***	12.410***	9.864***
	(0.081)	(1.962)	(1.504)
Controls	Yes	Yes	Yes
Mean of D.V.	2.97	54.0	25.28
Observations	1590	1517	1585

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Controls: gender, enrollment year, school enrolled, specialization

Why are foreign students more interested in academic careers?

- Selection:
  - Foreign students are higher ability or more science-oriented, either because of selection into migration, or because it is tougher for them to be admitted into U.S. PhD programs (Gaule & Piacentini, 2013, Stuen, Mobarak & Maskus, 2012)
- Incentives – visa policies:
  - Foreigners need to maintain legal visa status, which might be easier if they stay in academia (universities are not subject to H1-B cap) (Stephan and Ma 2005)

Foreign students appear be higher ability, more science-oriented

	(1) GRE score (self-reported)	(2) Pub in Nature/Science/Cell	(3) Pub in top chemistry journal
Foreign student	85.217***	0.007**	0.012
	(6.829)	(0.003)	(0.017)
Controls	Yes	Yes	Yes
Mean of D.V.	772	0.003	0.093
Observations	713	1605	1605

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

- Controls: gender, enrollment year, school enrolled, specialization

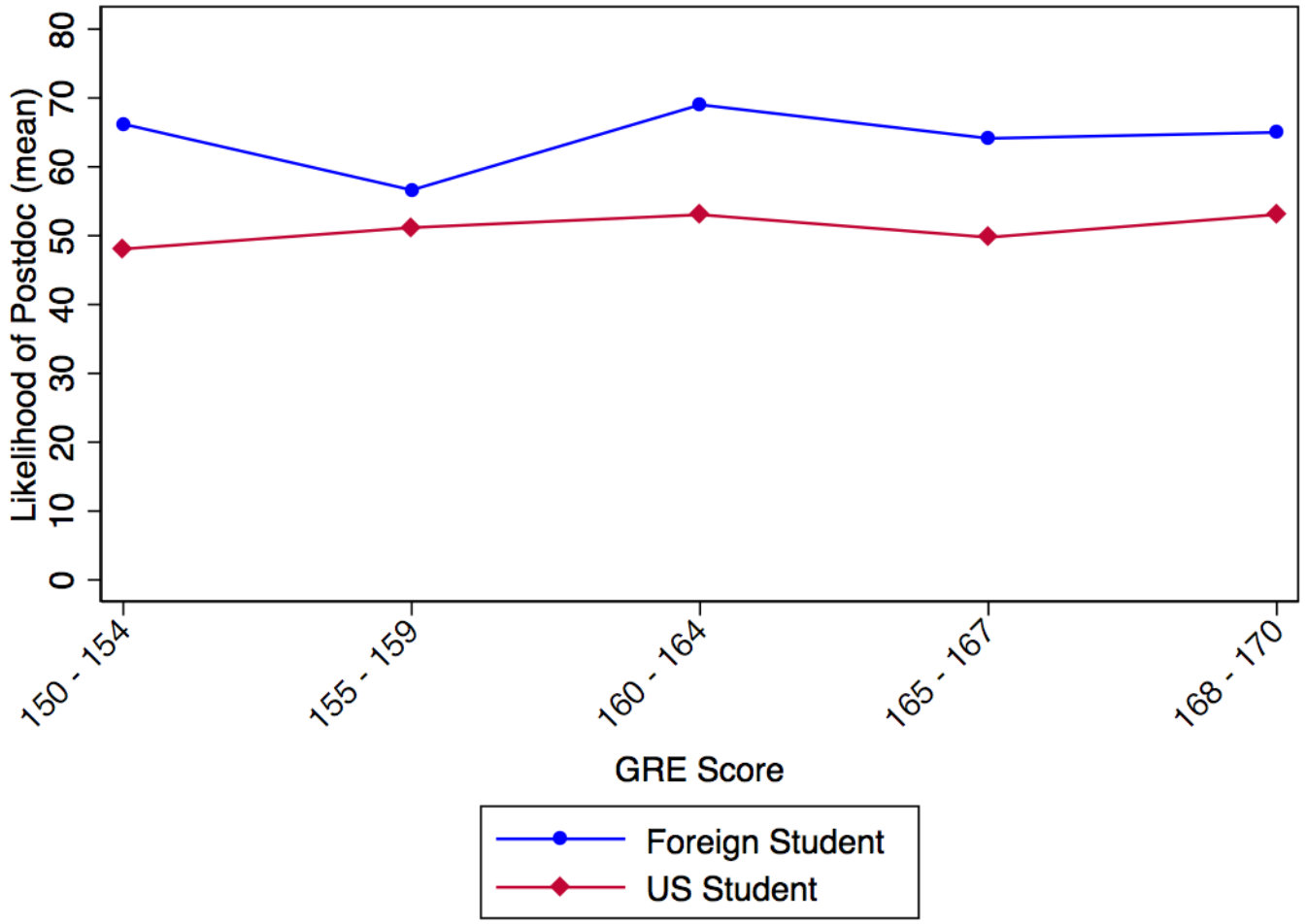
Foreign students are still more likely to prefer academia controlling for these factors

	(1)	(2)	(3)	(4)	(5)	(6)
		Attractiveness of TT faculty job (1-5 Likert)		Likelihood of doing a postdoc		Chances of choosing postdoc option (among 3 choices)
Foreign student	0.829***	0.721***	12.410***	11.246***	9.864***	8.405***
	(0.081)	(0.085)	(1.962)	(2.059)	(1.504)	(1.585)
Ability controls	No	Yes	No	Yes	No	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1590	1590	1517	1517	1585	1585

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

- Controls: self-reported GRE, Pub in Nature/Science/Cell, Pub in top chemistry journals
- Other controls: gender, enrollment year, school enrolled, specialization

Foreign students more likely to prefer postdoc at all ability levels (GRE)



Outline

1. Motivation and overview
2. Details about survey
3. Comparing the career preferences of foreign and domestic students
4. **Comparing the location preferences of foreign and domestic students**
5. Revealed preferences ranking of U.S. and foreign universities for postdoc

Methods: Location Preferences

- We use a novel approach based on a hypothetical choice method
- How likely (in terms of percent chances out of 100) they are to choose a postdoc position when given pairs of postdoc offers
  - *Offers include postdoc positions in top-50 Chemistry departments both in U.S. and non-U.S. universities (based on the Shanghai ranking)*

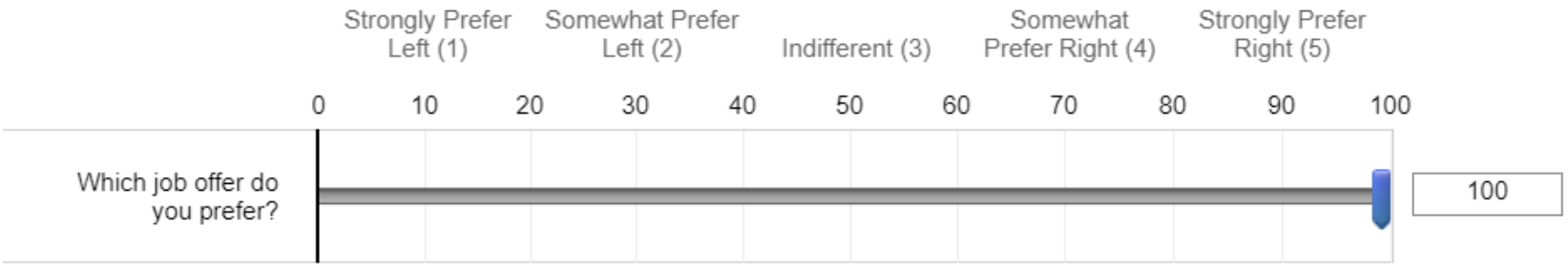
Methods: Location Preferences

- We choose postdocs as it's comparable across different locations in type of work and salary
- In this field (Chemistry), it is basically required to do a postdoc in order to continue a research career and obtain a faculty position

Example: Hypothetical choice question

Now, we will ask you to evaluate a series of job offers. Suppose you had the following two job offers. Please rate how likely you are to accept one of them rather than the other.

Job Offer #1	Job Offer #2
Employer: University of Toronto **Location: Toronto, Canada** **Job Title: Postdoctoral Research Fellow**	**Employer: Harvard University** **Location: Cambridge, MA, USA** **Job Title: Postdoctoral Research Fellow**



Data set up

- We asked five counterfactual choice questions to each respondent
- For each respondent, the counterfactual choices were randomly drawn between every pairwise combinations of the top 50 institutions in the Shanghai chemistry ranking
- We focus here on the 4,030 choices between one of U.S. universities (28) and one of foreign universities (22) in the top 50.

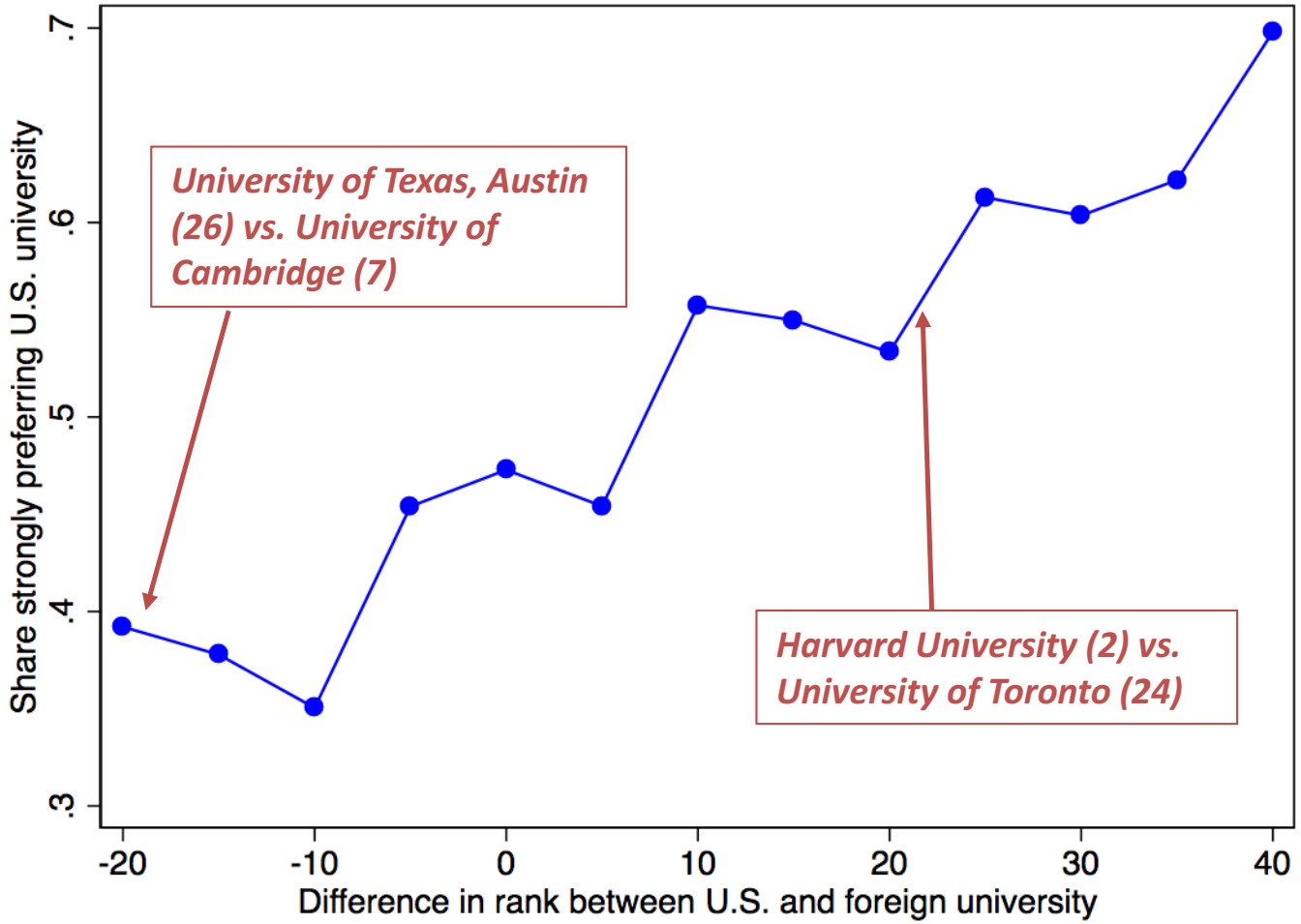
The Shanghai chemistry ranking

Academic Ranking of World Universities in Chemistry - 2015

Mathematics | Physics | Chemistry | Computer | Economics | Methodology | Statistics

World Rank	Institution	Country /Region	Total Score	Score on Alumni ▼
1	University of California, Berkeley		100.0	94.3
2	Harvard University		95.9	100.0
3	Stanford University		95.2	57.7
4	California Institute of Technology		86.8	57.7
5	Northwestern University		82.9	0.0
6	Massachusetts Institute of Technology (MIT)		80.9	0.0
6	University of Cambridge		80.9	66.7
8	Swiss Federal Institute of Technology Zurich		76.1	33.3
9	Kyoto University		74.9	33.3
10	University of Pennsylvania		72.6	57.7
11	University of California, Los Angeles		70.3	0.0
12	Yale University		69.6	57.7
13	University of California, Santa Barbara		68.9	0.0
14	Technical University Munich		66.5	66.7
15	Cornell University		66.1	81.6

Preference for the U.S. university vs. rank difference between U.S. and foreign university



Comparing the location preferences of foreign and domestic students

$$PreferUS_{ij} = \beta * foreign_i + \partial * controls_i + \gamma_j + \varepsilon_{ij}$$

- We consider foreign and domestic students *i* facing the exact same counterfactual choice *j* between a U.S. university and foreign university (choice FE)
- Additional controls for department enrolled in, year in the program, specialization, gender and marital status
- Also include ability and sector preference measures

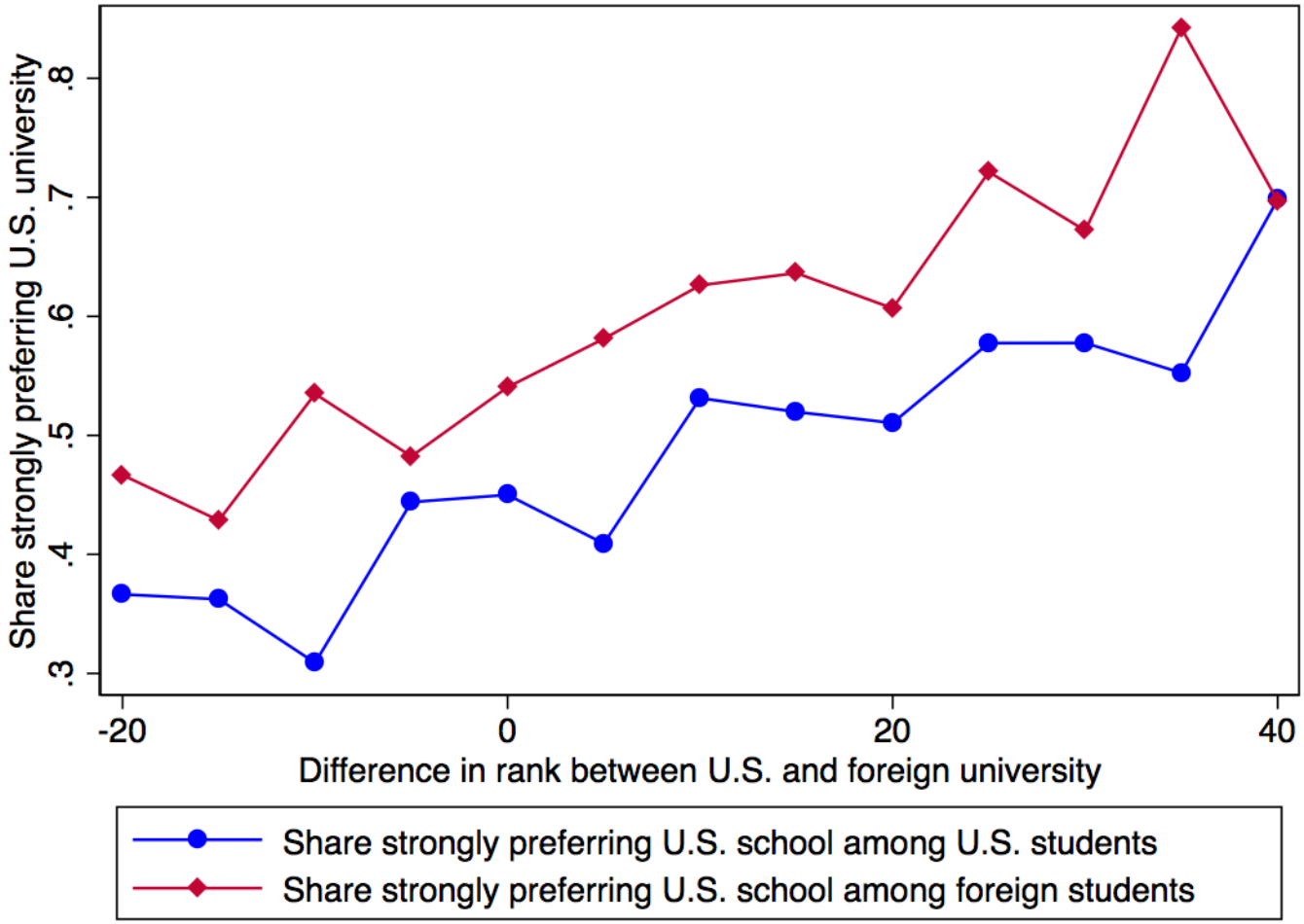
Results

	(1) Strongly prefer U.S. university	(2) Strongly prefer foreign university
Foreign student	0.131***	-0.072***
	(0.020)	(0.016)
Choice Fixed Effects	Yes	Yes
Controls	Yes	Yes
Mean of D.V.	0.51	0.20
Observations	4030	4030

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

- Foreign students are 13 percentage more likely to prefer the U.S. university for a postdoc
- Similar estimates when controlling for ability and sector preferences

Foreign prefer US universities more than US students at all ranks



Outline

1. Motivation and overview
2. Details about survey
3. Comparing the career preferences of foreign and domestic students
4. Comparing the location preferences of foreign and domestic students
5. **Revealed preferences ranking of U.S. and foreign universities for postdoc**

Constructing a revealed-preferences ranking of universities

- We construct a revealed-preferences ranking of universities as locations to do a chemistry postdoc
  - Initially pooling all students together then separately for American and foreign students
- Approach: using the 'Elo' system initially used to rank chess players but since used in American college football and other sports as well as on the Topcoder platform
- The method is analogous to Avery et al.'s (2012) revealed preference ranking of U.S. colleges (though they rely on actual instead of counterfactual choices)

The ranking system in action

- The initial assumption is that all universities are equally desirable (equal number of points)
- Every time we observe a student choosing a university over another, the number of points of the ‘winning’ university goes up and that of the ‘losing’ university goes down
- The number of points lost or gained depends on the points differential (initially zero but then continuously updated)
- Implemented through a custom-build Python script

Top 10 schools in the revealed preferences ranking

Rank	University	Elo points
1	Caltech	1852
2	MIT	1799
3	UCSD	1775
4	Northwestern University	1749
5	UCSB	1749
6	Harvard University	1745
7	Stanford University	1743
8	UCLA	1743
9	Yale University	1732
10	Berkeley	1731

Result: intensity of preferences across schools

- Besides generating an ordinal ranking, this system can also measure the relative attractiveness (and generate predictions) between any two pairs of school based on the ELO points differential
- Examples:
  - MIT (1799) versus Colorado (1704): 64% chance MIT will be chosen
  - MIT (1799) versus Georgia Tech (1605): 76% chance MIT will be chosen
  - MIT (1799) versus Florida (1495): 85% chance MIT will be chosen

Computing the revealed preferences separately for U.S. and foreign students

	Revealed preferences ranking - U.S. students	**Revealed preferences rankings - foreign students**
1	California Institute of Technology	Harvard University
2	University of Colorado at Boulder	California Institute of Technology
3	University of Cambridge	MIT
4	MIT	Berkeley
5	UCSD	Stanford University
6	Northwestern University	University of California, Santa Barbara
7	University of California, Irvine	UCSD
8	Stanford University	Yale University
9	UCLA	University of Southern California
10	Berkeley	UCLA

Comparing the revealed preferences to the Shanghai ranking (chemistry subject)

- Shanghai ranking: based on research output only (pubs, cites, pubs in top journals, awards)

- Revealed preferences: reflects location preferences as well as research

Revealed preferences for U.S. and foreign students

	Shanghai Chemistry rankings	Revealed preferences ranking - U.S. students	Revealed preferences rankings - foreign students
1	University of California, Berkeley	California Institute of Technology	Harvard University
2	Harvard University	University of Colorado at Boulder	Caltech
3	Stanford University	University of Cambridge	MIT
4	Caltech	MIT	Berkeley
5	Northwestern University	UCSD	Stanford University
6	MIT	Northwestern University	UCSB
7	University of Cambridge	University of California, Irvine	UCSD
8	Swiss Federal Institute of Technology Zurich	Stanford University	Yale University
9	Kyoto University	UCLA	USC
10	University of Pennsylvania	Berkeley	UCLA

Comparing the revealed preferences to the Shanghai ranking

- On average American universities are two ranks higher than their Shanghai ranking in the revealed preference of Americans
- However, American universities are four ranks higher than their Shanghai ranking in the revealed preferences of foreigners
- Both foreign and domestic students value U.S. locations but the foreign students more so
- Some differences within the set of American universities across the two groups of students

Selected international schools across the three rankings

	Shanghai Chemistry rankings	Preferences - U.S. students	Preferences - foreign students
University of Cambridge	7	3	17
Swiss Federal Institute of Technology Zurich	8	15	20
Kyoto University	9	46	47
Technical University Munich	14	25	26
University of Oxford	17	22	16
University of Strasbourg	19	31	27
University of Toronto	24	29	23
King Abdulaziz University	36	50	50
Zhejiang University	38	49	49
Weizmann Institute of Science	42	47	46
Monash University	44	37	38

Results Summary

- Unique survey data and methods allowed us to measure preferences of foreign vs. US Chemistry PhDs:
  - Foreign students are more interested in academic careers (postdocs)
  - Far from being a ‘flight risk’, foreign students have a stronger preference for U.S. universities than U.S. students
  - U.S. Universities are perceived as more desirable as a place to do a postdoc than a bibliometrics-based ranking suggests