The Supply of Innovators / Immigration & Innovation

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NBER Innovation Research Boot Camp
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Policies to encourage innovation?

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Policies to increase innovation?

- Patent laws: grant temporary monopolies to inventors of new products
- Tax incentives for R&D
- Grants to fund basic research at universities
- Industrial policy targeting specific industries key for rapid tech. progress
- Increase skilled workers/skills of workers - through education, immigration, and ?

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Outline

1. The supply of innovators & knowledge production
2. Earnings & entry into science
   - Cobwebs
   - Compensating differentials
   - Roy model
   - Biased beliefs
   - Diversity (Lost Einsteins / Ramanujans)
3. Mobility / Immigration
   - Immigration
   - Non-competes / monopsony
4. Doing Empirical Research in Labor & Innovation

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The Supply of Innovators

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Recall from earlier in the course

- In a simple version of the knowledge production function (Romer, 1990), $\dot{A}$ is the number of new ideas produced, L_A is the number of people searching for new ideas (effort), A is the current stock of ideas, $\bar{\delta}$ is the rate at which new ideas are discovered:

$$\dot{A} = \bar{\delta} A L_A$$

- Today we will examine L_A more closely

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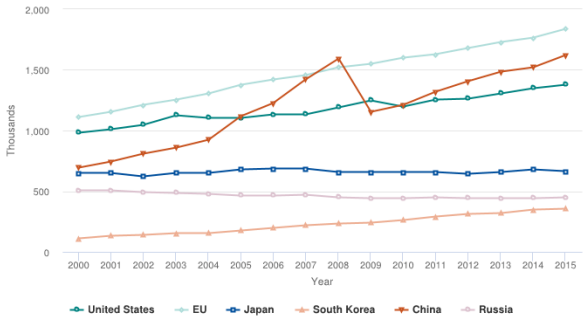
Estimated Researchers



EU = European Union.

Note(s): Data are not available for all regions or countries for all years. Researchers are full-time equivalents. Counts for China before 2009 are not consistent with Organisation for Economic Co-operation and Development (OECD) standards. Counts for South Korea before 2007 exclude social sciences and humanities researchers.

Source(s): OECD, Main Science and Technology Indicators (2017/1), https://www.oecd.org/sti/msti.htm, accessed 22 September 2017.

Science and Engineering Indicators 2018

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The role of human capital

- How important is human capital in the knowledge production function?
- Waldinger (2016) estimates the effects of (dept-level) shocks to human and physical capital during WWII

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The role of human capital

- How important is human capital in the knowledge production function?
- Waldinger (2016) estimates the effects of (dept-level) shocks to human and physical capital during WWII
  - Dismissal of Jewish scientists in Nazi Germany between 1933 and 1940 as a shock to human capital (33% decline in pubs)
  - Destruction of universities during the Allied bombing campaign of WWII as a shock to physical capital (6% decline in pubs)

"Dismissal of scientists in Nazi Germany contributed about nine times more to the decline of German science than physical destruction during WWII"

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TABLE 2.—DISMISSAL AND BOMBING SHOCKS ACROSS SCIENCE DEPARTMENTS

	Physics				Chemistry				Mathematics					
	Dismissal Shock			Bombing Shock	Dismissal Shock			Bombing Shock	Dismissal Shock			Bombing Shock	Total Destruction	
University	Number of Scientists (1931)	Dismissed 1933–1940 Number	Dismissed 1933–1940 Percentage	Destruction 1940–1945 in Percentage	Number of Scientists (1931)	Dismissed 1933–1940 Number	Dismissed 1933–1940 Percentage	Destruction 1940–1945 in Percentage	Number of Scientists (1931)	Dismissed 1933–1940 Number	Dismissed 1933–1940 Percentage	Destruction 1940–1945 in Percentage	University Destruction in Percentage	City Destruction in Percentage
Aachen TU	5	1	20.0	20.4	11	1	9.1	52.4	6	2	33.3	25.0	70	49
Berlin	41	10	24.4	10.0	47	16	34.0	65.0	14	5	35.7	10.0	45.8	37
Berlin TU	30	9	30.0	25.0	41	11	26.8	11.1	17	5	29.4	48.0	48	37
Bonn	10	1	10.0	50.0	14	2	14.3	20.6	8	1	12.5	20.6	40	24
Braunschweig TU	5	0	0	90.0	11	0	0	47.0	2	0	0	25	70	26
Darmstadt TU	10	3	30.0	m	12	4	33.3	m	5	1	20.0	m	75	46
Dresden TU	11	1	9.1	100.0	17	1	5.9	5.0	8	0	0	100.0	65	39
Erlangen	5	0	0	0	9	1	11.1	0	3	0	0	0	0	4.8
Frankfurt	13	2	15.4	37.0	18	5	27.8	57.0	8	4	50.0	27.0	60	32
Freiburg	5	1	20.0	100.0	11	2	18.2	60.0	5	1	20.0	85.0	72.5	28
Giessen	6	1	16.7	50.0	9	0	0	100.0	4	0	0	50.0	67.5	53
Göttingen	20	8	40.0	0	17	3	17.6	0	16	10	62.5	0	1.7	2.1
Graz	7	1	14.3	10.0	8	0	0	0	6	0	0	0	5	33
Graz TU	1	0	0	0	7	0	0	0	5	0	0	50.0	20	33
Greifswald	7	0	0	0	4	0	0	0	4	0	0	0	0	0
Halle	4	0	0	0	7	1	14.3	0	5	1	20.0	0	5	5
Hamburg	15	2	13.3	30.0	12	2	16.7	30.0	8	1	12.5	15.0	50	54
Hannover TU	4	0	0	22.2	10	0	0	37.5	4	0	0	22.2	41.3	47
Heidelberg	6	0	0	0	19	2	10.5	0	5	3	60.0	0	0	1
Innsbruck	6	0	0	0	8	0	0	50.0	5	0	0	0	m	60
Jena	14	1	7.1	0	10	0	0	62.5	5	0	0	50.0	87.3	20
Karlsruhe TU	5	1	20.0	75.0	16	5	31.3	100.0	5	1	20.0	75.0	70	26
Kiel	7	1	14.3	62.5	8	0	0	50.0	5	2	40.0	75.0	60	41
Köln	6	1	16.7	66.7	6	0	0	50.0	5	1	20.0	0	20	44
Leipzig	12	2	16.7	41.0	21	2	9.5	100.0	8	2	25.0	0	70	19
Marburg	5	0	0	0	8	0	0	50.0	6	0	0	0	16.3	4
München	11	2	18.2	42.0	19	3	15.8	95.0	8	1	12.5	70.0	70	32

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Who belongs in L_A?

- What does it mean to be an innovation worker (as opposed to a production worker)?
- What are the factors that shape *the supply of innovators*?
- $\bar{\delta}$ tells us something about how productive we expect these innovators to be once they have made their choice of sector

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But cumulative innovators need to bring themselves to the frontier before they can be productive

- The "gestation period" is extremely long (and getting longer)
- The job prospects at the time of graduation are difficult to predict in advance
- Aspirants often lack reliable information regarding the job outcomes of recent graduates
- Career decisions in this market may largely be made in the dark due to scientists' "love" of the subject

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Earnings & Entry Into Science

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Who Selects into the Ideas Sector?

- Do institutions provide the right incentives for the right people to work on innovation?
- What kind of policies and shocks stimulate entry into STEM careers?
- Who is in the pipeline that produces innovators?
- Are there barriers limiting diversity in the pool of innovators?

Patent office?

Academia?

Hedge fund?

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Earnings & Entry Into Science

Cobwebs

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Post WWII Engineering Labor Market

- In 1940-1970s, series of surpluses and shortages in the U.S. engineering labor market
- Freeman (1976) uses a cobweb model to explain the changes in the supply of engineers
- Salaries *4 years earlier* determines entry decisions

Figure 1. Proportion of Freshmen in Engineering and Percentage Obtaining Degrees Four Years Later, 1948–72.

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The Cobweb Model

- Many labor markets don't adjust quickly to shifts in supply & demand (e.g. engineering)
- Two assumptions of the cobweb model:
  - Time is needed to produce skilled workers.
  - People decide to become skilled workers by looking at conditions in the labor market at the time they enter school

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The Cobweb Model

- A "cobweb" pattern forms around the equilibrium, which arises when people are misinformed
- The model assumes naïve workers who do not form rational expectations - they do not correctly perceive the future and understand the economic forces at work

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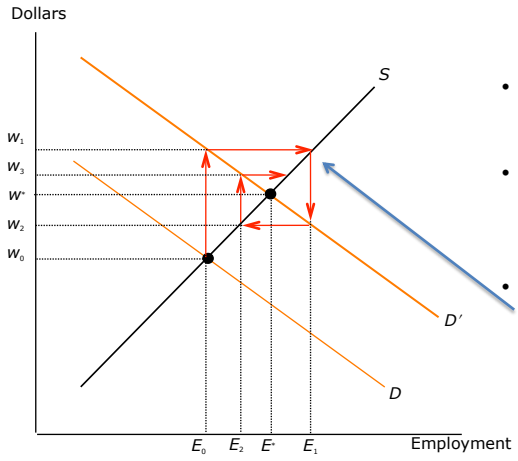
The Cobweb Model (cont.)



- The initial equilibrium wage in the engineering market is w_0 and E_0 engineers are produced
- The demand for engineers shifts to D'
- New engineers are not produced instantaneously, so SR supply curve is inelastic at E_0 (wage rises to w1)
- At w1, E_1 students will enter engineering school, but when they enter the market, they earn only w2

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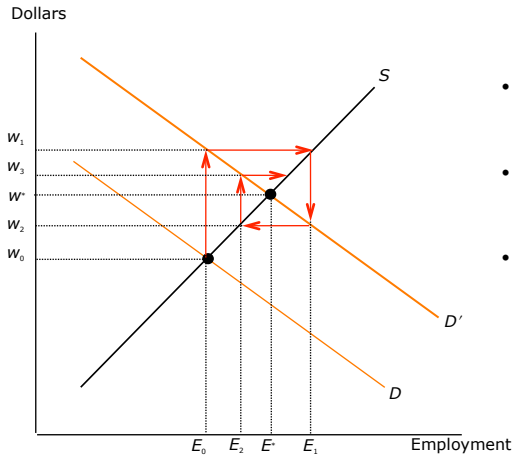
The Cobweb Model (cont.)



- The next generation of students will see the wage of w2 and only E2 students become engineers
- But they earn a higher wage of w3, and so on
- Since they mis-judge future opportunities, a cobweb is created
- In the long run, the initial demand shock leads to an equilibrium wage of w* and employment E* (both are higher than initially, but process was one of booms and busts)

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Earnings & Entry Into Science

Compensating Differentials

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Do Scientists "Pay" to Do Science?

- Compensating wage differentials arise to compensate workers for non-wage characteristics of the job
- Adam Smith argued that it is the advantages and disadvantages of the job is what must be equated across jobs
  - Firms offering unpleasant jobs must compensate workers for the *unpleasantness of the job*.
  - Firms that offer pleasant working conditions may be able to compensate their workers less, effectively making those workers *pay for the pleasantness of the job*
- Empirically challenging to estimate the "price" for nonwage characteristics

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Set-Up of Models of Compensating Wage Differentials

- Worker preferences vary among workers
- Job attributes (amenities) vary across jobs/firms
- Equilibrium concept: A match is made when, among feasible choices, worker finds the job attributes (including the wage) to be most beneficial and the employer finds the worker's characteristics to be the most profitable
- Total compensation = Full Wage = Wage for Labor Services + "Wages" for Job Attributes

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Stern (2004): "Do Scientists Pay to Do Science?"

- Estimate 'wage-science' tradeoff facing individual post-docs in biology with different job offers with different amenities
- Novel identification approach: leverage info on multiple offers for the same individual to calculate
- Based on survey data where respondents reported on each offer – salary and evaluated job offers on a number of dimensions (66 individuals, 164 offers)
- With individual FEs, estimate of WTP - ~ 20-25% lower wage to do own research (permit publication)

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Table 3 Hedonic Wage Regression: Overall Sample Dependent Variable = LN(SALARY), # of Observations = 121

	Permission to publish			Combination model	Science index model	
	(3–1)	(3–2)	(3–3)	(3–4)	(3–5)	(3–6)
	Baseline (NO FE)	Baseline (w/FE)	Full model (w/FE)	Full model (w/FE)	Full Model (w/FE)	Full Model (w/FE)
PERMIT_PUB	0.027	**−0.266**	**−0.191**	−0.089		
	(0.186)	**(0.114)**	**(0.105)**	(0.103)		
CONTINUE RESEARCH				**−0.134**		
				(0.060)		
INCENT_PUB				−0.036		
				(0.028)		
SCIENCE INDEX					**−0.114**	−0.078
					(0.053)	(0.057)
EQUIPMENT				**0.063**	**0.057**	**0.053**
				(0.033)	**(0.030)**	**(0.031)**
CONTROLS						
PROMOTION			**0.041**	**0.046**	**0.042**	0.031
			(0.025)	**(0.021)**	**(0.021)**	(0.023)
STOCK_DUMMY			**0.196**	**0.234**	**0.260**	**0.190**
			(0.085)	**(0.074)**	**(0.067)**	**(0.077)**
ACCEPTED JOB			−0.013	0.002	−0.0001	−0.002
			(0.040)	(0.043)	(0.043)	(0.044)
JOBTYPE CONTROLS	no	no	yes (5; Sig.)	no	no	yes (5)
Individual fixed effects	no	yes (52; Sig.)	yes (52; Sig.)	yes (52; Sig.)	yes (52; Sig.)	yes (52; Sig.)
R-squared	0.001	0.915	0.955	0.958	0.954	0.958

Notes. Only persons with multiple job offers are included.
Standard errors are shown in parenthesis; significant coefficients (10%) are shown in bold.
Sig. stands for joint significance of fixed effects or job type controls (at 10% level).

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Earnings & Entry Into Science

Roy Model

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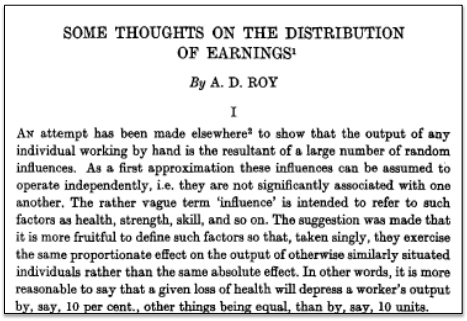
Roy Model

- The Roy Model describes how workers sort themselves across employment opportunities – based on returns (earnings) in different sectors
- Original ideas in Roy (1951) on workers choosing between hunting or fishing - then mainly used in immigration literature (Borjas, 1986)



SOME THOUGHTS ON THE DISTRIBUTION OF EARNINGS[1]

By A. D. ROY

I

An attempt has been made elsewhere[2] to show that the output of any individual working by hand is the resultant of a large number of random influences. As a first approximation these influences can be assumed to operate independently, i.e. they are not significantly associated with one another. The rather vague term 'influence' is intended to refer to such factors as health, strength, skill, and so on. The suggestion was made that it is more fruitful to define such factors so that, taken singly, they exercise the same proportionate effect on the output of otherwise similarly situated individuals rather than the same absolute effect. In other words, it is more reasonable to say that a given loss of health will depress a worker's output by, say, 10 per cent., other things being equal, than by, say, 10 units.

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Roy Model

- Key insight: whether innovators are positively or negatively selected depends on the correlation between the value of ability in the production sector and the value of ability in the idea sector
- -> self-selection will not always imply that innovators are the most able individuals from the production sector

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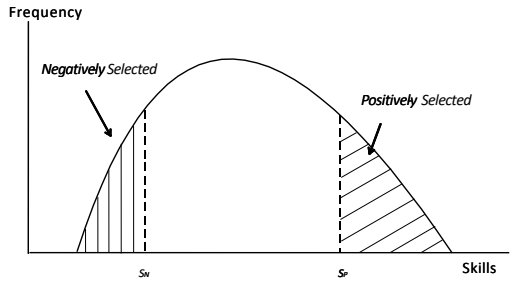
Theoretical Framework: Roy Model

- Each worker makes a decision on which sector to work in by comparing earnings in each sector
  - Positive selection: the very skilled choose a given sector
  - Negative selection: the less skilled choose a given sector



If workers have above-average skills, they are positively selected.
If workers have below-average skills, they are negatively selected.

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Evidence from MIT graduates (Shu 2015)

Evidence that finance does not attract the "best and brightest" STEM students from MIT at college graduation, though it may attract those with more finance-relevant skills

- Finance and S&E demand substantially different skills
- The best STEM students have a preference for going into S&E

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Key findings: Evidence of negative correlation of skills

On average, graduates entering S&E:

- Have better academic records in high school
- Focus more on developing academic skills during college

On average, graduates entering finance:

- Have more leadership experiences in high school
- Focus more on developing social skills during college

Differences in skill development appear very early (at college entry or in high school)

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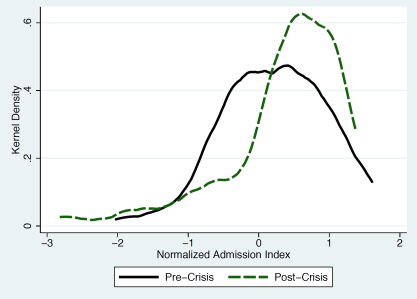
Who is the marginal financier?

- Sample: students whose initial major is S&E, but enter finance after graduation
- Post-crisis, ones who stay in finance have better academic qualifications



Shu, 2015

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Earnings & Entry Into Science

Biased Beliefs

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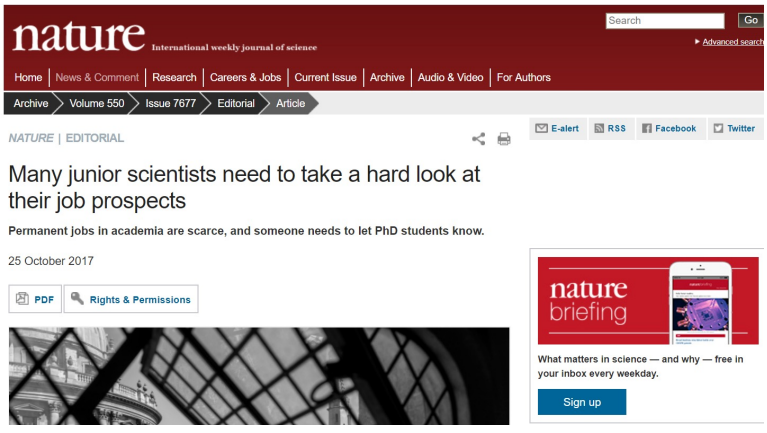

http://www.nature.com/news/many-junior-scientists-need-to-take-a-hard-look-at-their-job-prospects-1.22879

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The academic job market

- PhD/postdoc training largely designed to prepare individuals for academic careers
- Less than 10% of PhD graduates end up in tenure-track faculty positions in research-intensive U.S. universities (approx. 200 R1/2 universities)
- In 2016, 2,700 new Chemistry PhDs, but only 152 openings in research universities

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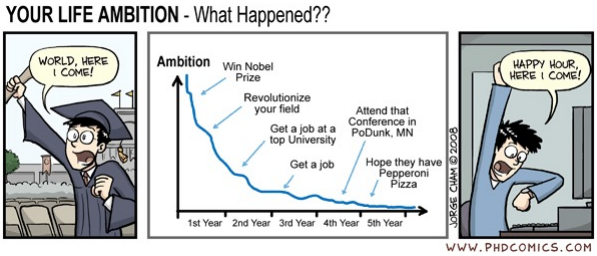

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CAREERS | TAKEN FOR GRANTED

A trend toward transparency for Ph.D. career outcomes?

7 MAR 2018 • BY BERYL LIEFF BENDERLY

ISTOCK.COM/SASINPARAKSA

For decades, blue ribbon reports, studies, panels, and commissions have bemoaned universities' lack of transparency about the career prospects of their Ph.D. recipients and postdocs. In particular, experts have criticized institutions' failure to track and report how their doctoral and postdoctoral alumni fare in the labor market. As administrators at 10 U.S. research institutions warned in a *Science* article this past December, without knowing

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Biased Beliefs

- Growing literature showing that students are not fully informed when making educational choices; choices can be impacted by the provision of accurate information (Jensen, 2010; Hoxby & Turner, 2015; McGuigan, McNally & Wyness, 2014; Wiswall and Zafar, 2015)

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Ganguli, Gaule and Vuletić Čugalj (2022): "Chasing the Academic Dream: Biased Beliefs and Scientific Labor Markets"

- *Does providing objective information about the chances of getting a faculty job influence PhD students' beliefs and career preferences?*
- Baseline survey:
  - Elicited beliefs and career preferences of 1,330 PhD students in a major STEM field (Chemistry) in 2017 from top 54 U.S. chemistry departments
- Randomized information intervention – 2 treatments providing *structured* and *non-structured* information about careers:
  - Actual historical academic placement records by program
  - Link to scientist profiles on American Chemical Society (ACS) webpage
- Follow-up survey one year after the intervention
- Match 2 cohorts to actual placement data 4 years later

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Results

- Sizable number of chemistry PhD students have biased beliefs; i.e. they are excessively optimistic
  - International students and students earlier in program are more likely to have overly-optimistic beliefs about the market
  - Having biased beliefs is correlated with stated preferences for staying in academia

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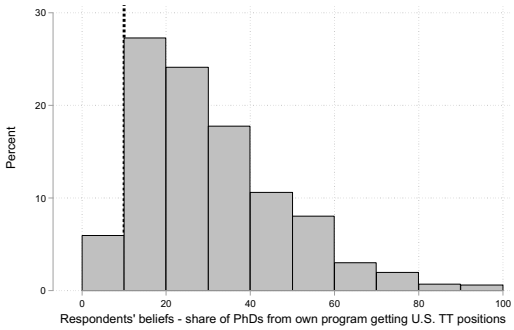
Baseline survey results – **beliefs about the market**



- Mean is 24.5%, Median is 20%
- Approx. 5% of graduates actually get the tenure track research position
- This suggests biased beliefs about the market as a whole (vs. own overconfidence)

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Results

- The information intervention led to an adjustment in:
  - Beliefs about *own* chances of becoming faculty but not about the market
  - Preferences for non-academic careers
  - No detectable impacts on actually doing a postdoc after graduation

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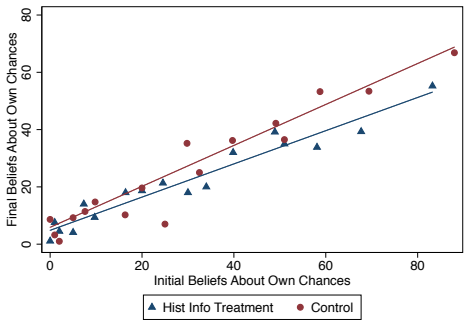
Final beliefs vs. initial beliefs: own



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Understanding the results

- Respondents updated their own beliefs, but no effects on actual choice of doing a postdoc
- There are other reasons people may do a postdoc
  - May be needed for industry careers
  - Visas
  - Family
- Career preferences may be stable

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Diversity in Science & Innovation Activities

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Diversity in Innovation

- Growing acknowledgement that more diversity in innovation activities is beneficial:
  - Impacts what is – and what is not – invented
  - Greater participation of women and underrepresented groups could increase economic growth
- But still large and persistent gender, racial/ethnic gaps among scientists and inventors

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Diversity in Patenting

- USPTO and other research has found that women, people of color, and lower-income individuals patent inventions at significantly lower rates than their representation in the population:
  - Less than 13 percent of all inventors who hold a U.S. patent are women. Women hold only 5.5 percent of commercialized patents.
  - Black and Hispanic college graduates patent at half the rate of White college graduates.
  - Patenting activity by Black inventors peaked in 1899 and has not recovered.
  - Children in families in the top one percent of income are ten times more likely to patent in their lifetimes than children in the entire bottom half of family income.

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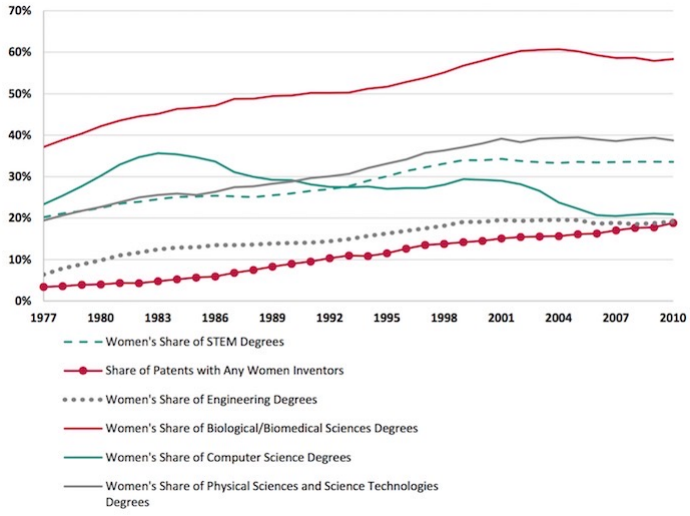
Gender gap in patenting



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Reasons for the Gaps?

- Lack of Role models
- Bias and Discrimination
- Preferences
- Culture
- Workplace flexibility - differs by occupation, specialization

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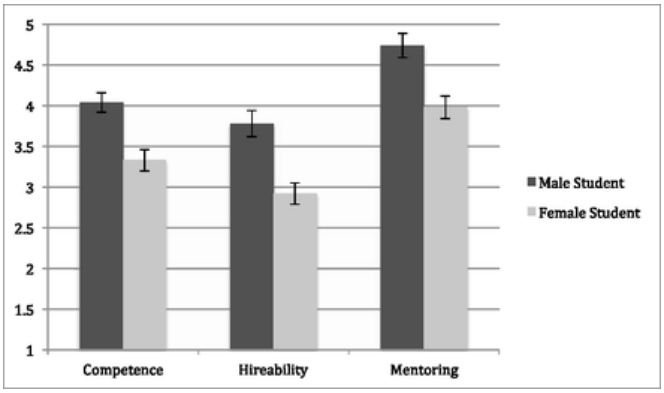
Bias: Moss-Racusin, et al. (2012)

"Science faculty from research-intensive universities rated the application materials of a student—who was randomly assigned either a male or female name—for a laboratory manager position. Faculty participants rated the male applicant as significantly more competent and hireable than the (identical) female applicant. These participants also selected a higher starting salary and offered more career mentoring to the male applicant. The gender of the faculty participants did not affect responses…"



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- More evidence is needed on the extent, reasons and implications of the gaps
- But USPTO doesn't collect data on gender and race /ethnicity of inventors..

What a Great IDEA! Collecting Data on the Diversity of Patent Inventors

By Tamara Fraizer on March 11, 2021

POSTED IN INCLUSION & DIVERSITY, PATENTS, USPTO

A bipartisan group of Senators, including the Chair and ranking minority member of the Subcommittee on Intellectual Property, has proposed legislation that would allow the US Patent & Trademark Office to collect demographic data on patent applicants. The bill, known as the Inventor Diversity for Economic Advancement Act of 2021 or, more simply, the "IDEA Act," comes as a response to increasing public concerns about the lack of diversity among inventors named on patents, and the inability of the USPTO to provide data to reliably assess the situation. The "idea" hearkens to a primary maxim of business that, "if you can't measure it, you can't improve it." Like many other government programs, it would empower the USPTO to collect such data on a voluntary basis, and require the USPTO to report on any such data provided.

The IDEA Act provides, specifically, as follows:

"*The Director shall provide for the collection of demographic information, including gender, race, military or veteran status, and any other demographic category that the Director determines appropriate, related to each inventor listed with an application for patent, that may be submitted voluntarily by that inventor.*"

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Konings, Samila and Ferguson (2021): "Who do we invent for? Patents by women focus more on women's health, but few women get to invent"

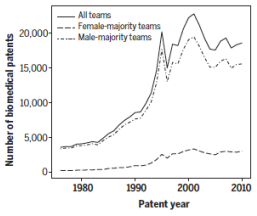

Fig. 1. Total number of U.S. biomedical patents over time along with the number of patents with majority female (≥ 50% women) and majority male (> 50% men) inventor teams. The figure includes 430,060 patents from 1976 through 2010.

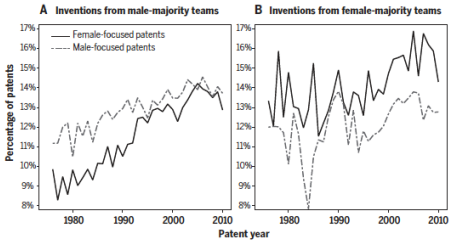

Fig. 2. Percentage of U.S. biomedical patents that are male-focused and female-focused broken out by the gender composition of the inventor team. (**A**) The percentages for patents with majority-male teams (>50% men). (**B**) The percentages for patents with majority-female teams (≥50% women).

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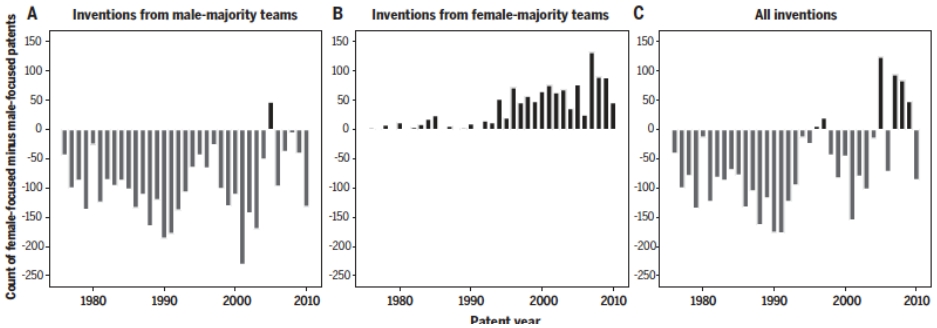
Koning, Samila and Ferguson (2021)



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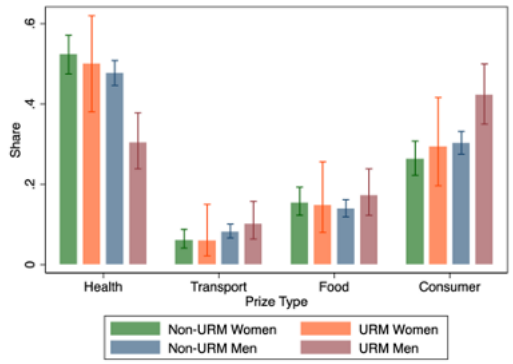
Self-reported Race/Ethnicity from student inventors (LMIT prize)

Figure 2. Share of Each Race/Gender Group by Prize Type Category



Note. Logit-transformed 95% confidence intervals.

Burrage et al (2022)

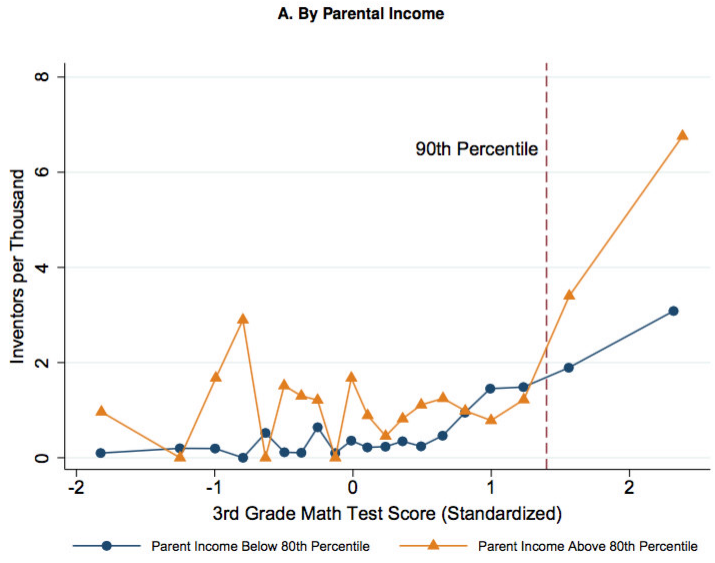
66

"Lost Einsteins/Ramanujans" Literature

- There are highly talented individuals getting "lost" and could contribute to knowledge productions
- Bell, et al (2018) examine who becomes an inventor in the US
  - Data on 1.2 million inventors from patent records linked to tax records to get measures of family income
  - Further analysis of a sample with 3rd grade math scores
- Agarwal and Gaule (2020): "Invisible Geniuses"
  - Use data from the IMO to show that talented individuals from lower-income countries are less likely to do PhDs and publish

67

FIGURE IV: Patent Rates vs. 3rd Grade Math Test Scores



Source: Bell, Chetty, Jaravel, Petkova, and Van Reenen

68

Talented youth: the International Mathematical Olympiad (IMO)

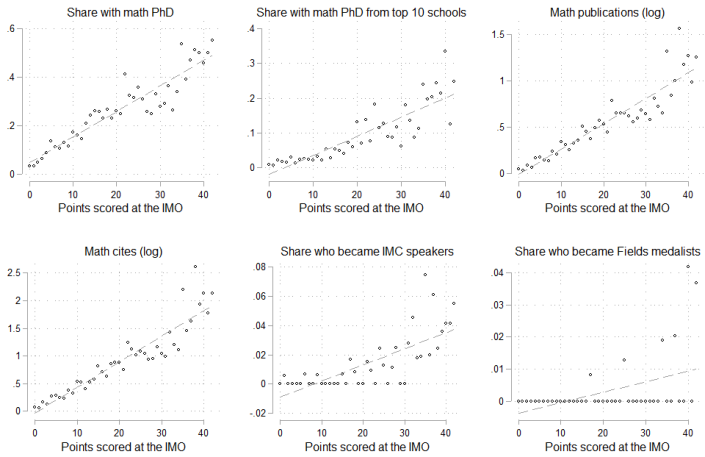
2019 Olympiad Q1

Let $\mathbb{Z}$ be the set of integers.
Determine all functions $f\colon \mathbb{Z} \to \mathbb{Z}$ such that, for all integers a and b,

$$f(2a) + 2f(b) = f(f(a+b))$$

69

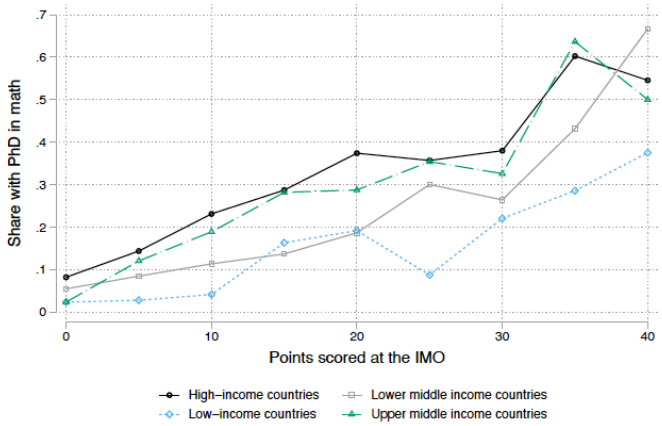
IMO scores predict subsequent career achievement



Agarwal and Gaule (2020)

70

Share getting a PhD in math by country income



Agarwal and Gaule (2020)

71

Agarwal, Ganguli, Gaule & Smith (2023): What are the constraints to migrating?

- Interviews suggested that financing constraints are an important barrier
- Key margin is students not even applying to U.S. undergrad programs
- Survey including hypothetical education offers

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Hypothetical choice questions

Q31 Suppose you had the choice between these two admission offers. Which one would you choose

College admission offer #1	**College admission offer #2**
University: Stanford University	**University:** New York University
Location: Stanford, USA	**Location:** New York, USA
Financial support: No financial support	**Financial support:** Full financial support

	Prefer left (1)	Indifferent (2)	Prefer right (3)
Which offer do you prefer? (1)	○	○	○

73

Hypothetical Choices: Choosing Funded Offer

	(1)	(2)
	Choose funded offer	
From a developing country	0.270***	0.196***
	(0.036)	(0.056)
Medalist		-0.113**
		(0.048)
Medalist x		0.136*
from a developing country		(0.072)
Choice FE	Yes	Yes
N	1,539	1,539
Mean of D.V.	0.54	0.54

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- Next we will think more about mobility of talent / foreign-born STEM workers…

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Mobility / Immigration

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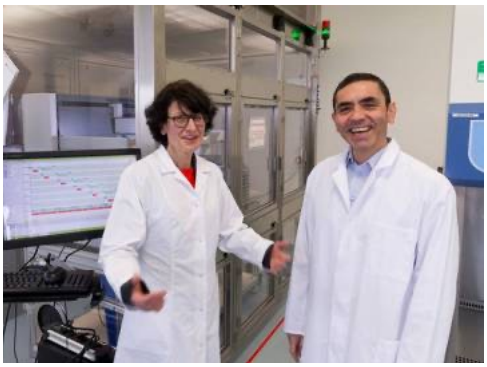
The immigrants behind the COVID-19 vaccines



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High Skilled Immigration

- One way to grow L_A is increased immigration
- Growing S&E labor force in the developing world, but many do not stay (e.g. Weinberg, 2010)
- Some countries concerned about "brain drain"; US & other countries benefitting
- Differences in productivity among scientists in around the world - due to selection, access to resources, to knowledge

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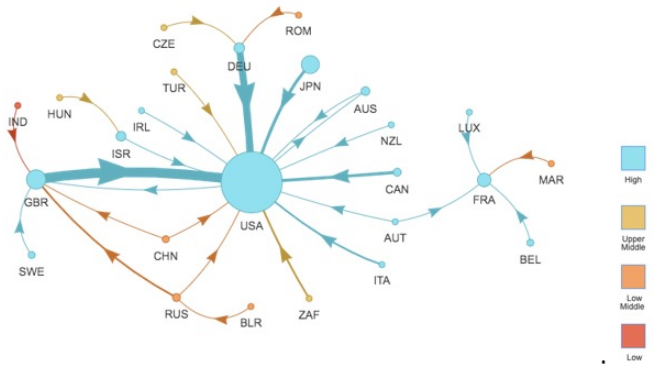
A few countries play a key role in attracting and nurturing talent

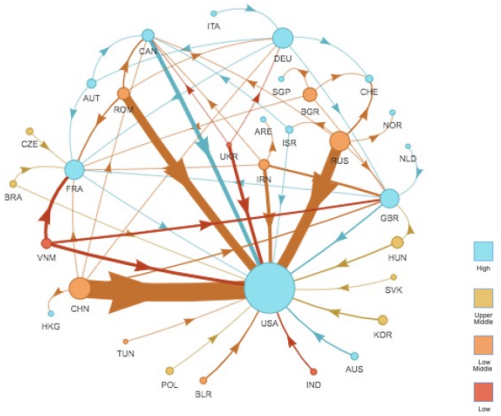


Migration flows among Nobel laureates in physics, chemistry and medicine

Agarwal, Ganguli, Gaule and Smith (2023)

79

A few countries play a key role in attracting and nurturing talent



Migration flows among IMO gold medalists

Agarwal, Ganguli, Gaule and Smith (2023)

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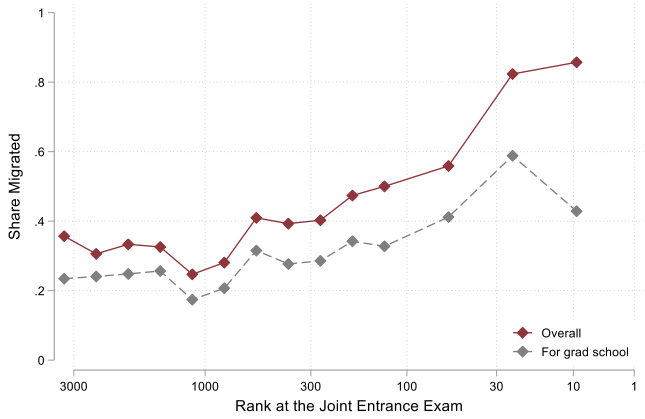
Share migrated by Joint Entrance Exam (JEE) Score



Choudhury, Ganguli and Gaule (2023)

81

Sending Countries: Brain Drain?

- Direct loss of human capital through emigration
- Decrease in supply of teachers and mentors to train next generation
- Émigrés act as channel for the younger generation to emigrate to pursue studies abroad through their networks

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Brain Gain? Potential Impacts on HC Accumulation

- Remittances may reduce credit constraints that allow for greater educational investments
- Return of emigrants after gaining further training abroad
- Increase in flow of knowledge from abroad through diaspora networks
- Impact on expectations - skilled migration prospects can induce investments in education

83

Literature on Impacts on Innovation in Host Countries

- Direct contributions of immigrants to science and innovation (+)
- Spillovers to natives (+)
  - Contributions to diffusion of knowledge
- Competition & crowd out (-)
- Impacts of immigration policies on the above

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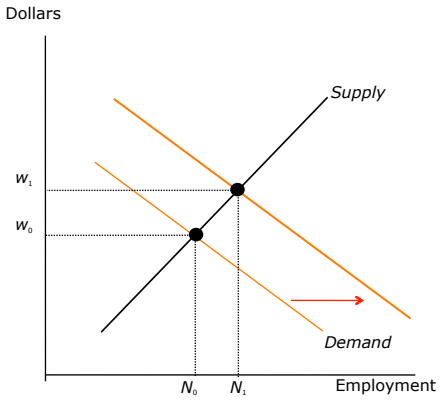
SR Impact of Immigration: Immigrants and Natives as **Complements**

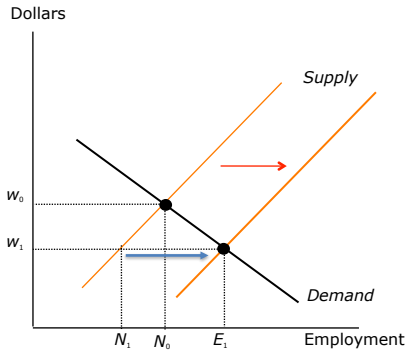


If immigrants and natives are complements, they do not compete in the same labor market.

- The labor market here denotes the supply and demand for native workers.
- Immigration makes natives more productive (they specialize, make better use of HC), shifting out the labor demand curve (recall VMP!)
- This leads to a higher native wage and to an increase in native employment.

85

SR Impact of Immigration: Immigrants and Natives as **Perfect Substitutes**



If immigrants and natives are perfect substitutes, they are competing in the same labor market.

- Immigration shifts out the labor supply curve to the right.
- The wage falls from w_0 to w_1, and total employment increases from N_0 to E_1.
- At the lower wage, the number of natives who work declines from N_0 to N_1.
- $E_1 - N_1$ is the number of immigrants (size of shift)

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View from the US

- US attracts 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, innovation and entrepreneurship (Levin & Stephan 1999, Hunt & Gauthier-Loiselle, 2010, Azoulay et al 2022)

87

Foreign-born disproportionately in science and engineering fields

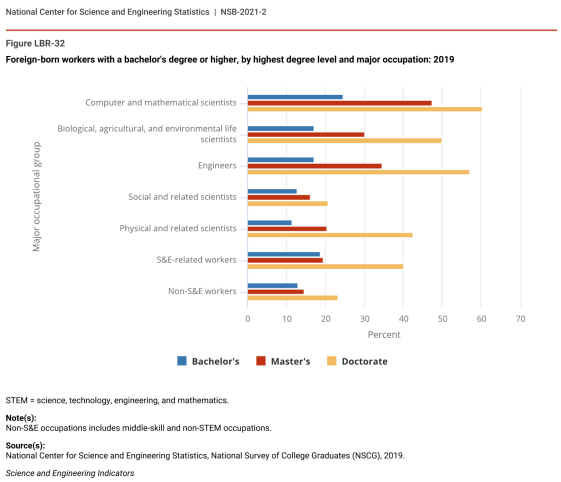

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TABLE 4—EFFECT OF IMMIGRANT STATUS ON PATENTING

	Any patent granted?				Any patent commercialized?	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Sample of college graduates (91,480 observations)						
Immigrant	0.0100*	0.0009*	−0.0007	−0.0005	0.0062*	−0.0004
	(0.0010)	(0.0005)	(0.0004)	(0.0003)	(0.0008)	(0.0003)
Pseudo-R^2	0.01	0.15	0.19	0.21	0.01	0.18
Panel B. Sample of post-college graduates (42,139 observations)						
Immigrant	0.0226*	0.0014*	0.0004	0.0005	0.0135*	0.0002
	(0.0018)	(0.0008)	(0.0006)	(0.0006)	(0.0014)	(0.0004)
Pseudo-R^2	0.02	0.21	0.24	0.26	0.02	0.21
Panel C. Sample of scientists and engineers (22,226 observations)						
Immigrant	0.0131*	0.0031	−0.0095*	−0.0074*	0.0063*	−0.0052*
	(0.0039)	(0.0031)	(0.0027)	(0.0026)	(0.0030)	(0.0020)
Pseudo-R^2	0.00	0.08	0.12	0.13	0.00	0.09
Major field of highest degree	–	Yes	Yes	Yes	–	Yes
Highest degree	–	–	Yes	Yes	–	Yes
Age, age^2, sex, employed	–	–	–	Yes	–	–

Notes: Marginal effect on immigrant dummy from weighted probits. All scientists and engineers are employed in the reference week. Post-college degrees include master's (including MBA), PhD, and professional. There are 29 major field of study dummies (we combine the two S&E teacher training categories into one). Standard errors are in parentheses.

*Indicates coefficients significant at the 5 percent level.

Hunt & Gauthier-Loiselle, 2010

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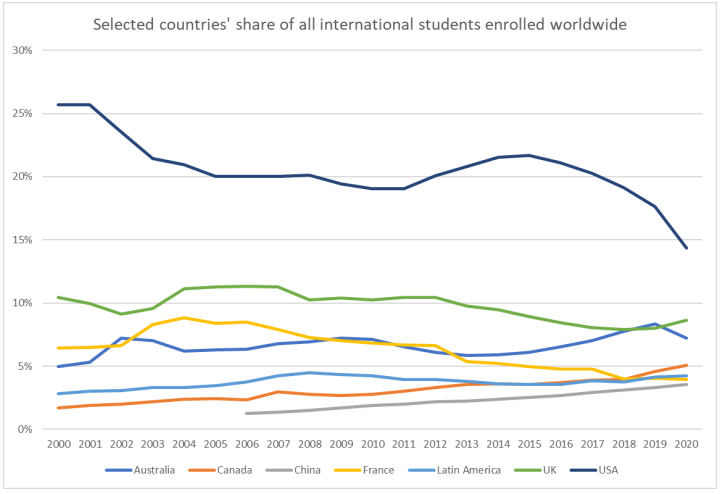

Ganguli and MacGarvie (2023)
Source: Author's calculations based on: *Inbound internationally mobile students by continent of origin*, by receiving country and year, UNESCO Institute of Statistics Database. http://data.uis.unesco.org/index.aspx?queryid=3806 (accessed 5/23/2023). Data on inbound students in the USA comes from Institute of International Education Open Doors Database, https://opendoorsdata.org/.

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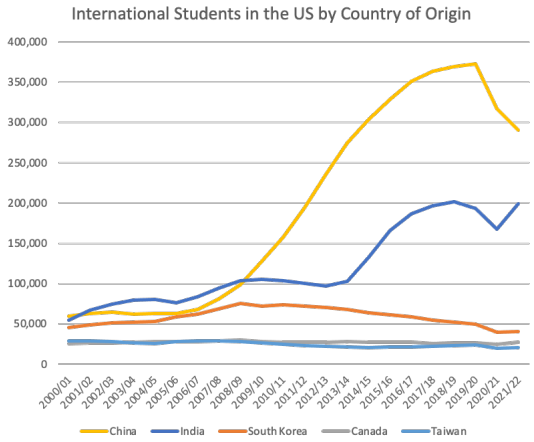

Ganguli and MacGarvie (2023)
Institute of International Education. (2022). "Leading Places of Origin of International Students, 2000/01 - 2021/22" Open Doors Report on International Educational Exchange. Retrieved from https://opendoorsdata.org/.

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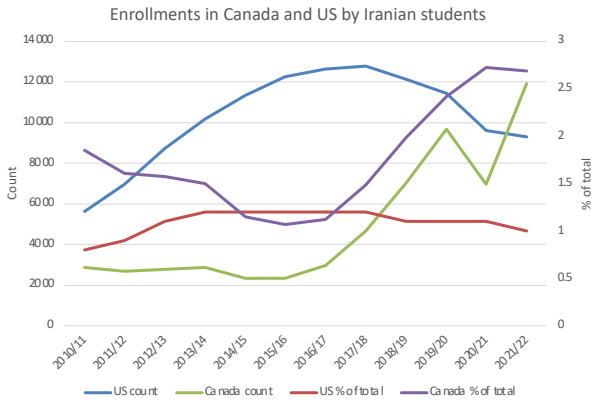
Source: https://www.politico.com/magazine/story/2017/10/01/donad-trump-making-canada-great-again-215651

92



Ganguli and MacGarvie (2023)
Source: Institute of International Education (2022).
Note: The years reported in the US data are all students enrolled in a given academic year, while the Canadian data report counts of incoming international students in the year the student's study permit became effective

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US Immigration Policies

- Many foreign-born workers in the US arrive as students
- Employment visas are very restricted (e.g. H1-B cap), but no limit on student visas
  - In 2010, 27% of U.S. IT workers had first come to the US on a student visa (Bound et al, 2017)
- STEM-OPT extension in 2008 (then 2012, 2016) provides grads in STEM fields with 29 months of work authorization after the completion of studies
  - Evidence the 2008 extension induced some international students to major in STEM (Amuedo-Dorantes, Furtado, and Xu, 2019)
- International PhD students in the US have stronger preferences for academia than similar US students, and decision to enter academia may be influenced by H1-B policy (Ganguli & Gaule, 2018; Amuedo-Dorantes & Furtado, 2019; Fry & Glennon, 2023)

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US Immigration Policies

- Per-country limits on the availability of permanent residency visas ("green cards") for China and India have led to long waiting periods
- Is limited availability of green cards for Chinese and Indian applicants leading to recent deceleration in enrollments in US universities?
  - 66% of Indian and 50% of Chinese business school applicants reported not being able to work in the US after graduation would prevent them from applying to US universities (GMAC, 2019)
  - Long waiting periods for green cards are associated with a greater propensity of US-trained STEM PhDs to leave the US (Khosla, 2019; Kahn & MacGarvie, 2020)

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US Immigration Policies

- In February 2021, Biden administration introduced the U.S. Citizenship Act (H.R. 1177), contained many immigration provisions including *exempting PhDs in STEM fields from green card limits* but Republican opposition
- Best opportunity for employment-based immigration looked like legislation for enhancing U.S. competitiveness in semiconductors (COMPETES Act), but final bill included no immigration measures (H.R. 4346, CHIPS Act of 2022)

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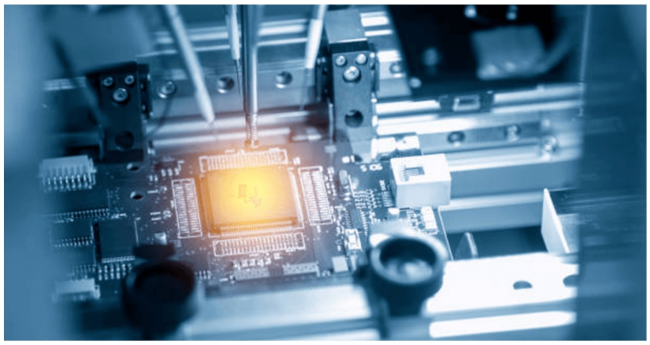
CHIPS and Science Act Spurs $140B in Private Semiconductor R&D Investments

by Naomi Cooper · May 23, 2023 · 1 min read



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Key U.S. Immigration Policies

- F-1 and M-1 visas are for students
- H-1B visas for people working in a specialty occupation, and they require a higher education degree or its equivalent
- J-1 visas are designed for work- and study-based exchange visitor programs
- L-1 visas are granted to intracompany transferees in roles requiring specialized knowledge

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H-1Bs

- H-1Bs are sponsored by firms
- An H-1B visa allows a skilled foreigner to enter the United States for 3 years
- Total number of H-1B visas awarded to firms is subject to a cap
- Different cap for visas given to workers who have a master's degree or higher from a US institution (the "advanced degree exemption")
- Many papers have identified the impacts of immigration through H-1Bs through variation in these caps over time

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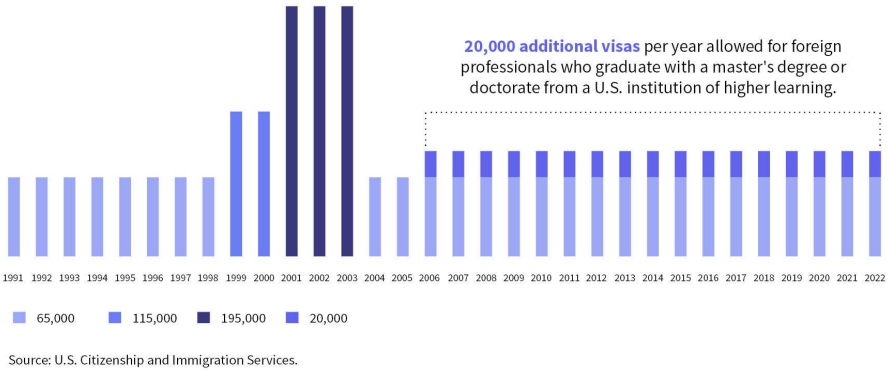
H-1B Visa Caps

FIGURE 1: ANNUAL CAP ON H-1B VISAS, FY 1991-2022



Source: U.S. Citizenship and Immigration Services.

https://www.americanimmigrationcouncil.org/research/h1b-visa-program-fact-sheet

100

Evidence on the impacts of H-1Bs

- Mixed evidence on how the H-1B visa program impacts innovation by US firms
  - Kerr and Lincoln (2010) show patents increase with higher H-1B visa admissions with a variety of approaches (including supply push approach leveraging shifts in national H-1B admissions and historically how dependent a city is on the program)
  - Doran, Gelber and Isen (2022) find no effects on patenting but negative employment effects comparing winning and losing firms in lotteries for H-1B visas (when the 65,000 cap is hit)

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Doran, Gelber and Isen (2022)

- Use administrative data on entrants in H-1B lotteries, matched to their tax filings and patenting
- Study 2006 and 2007 when the H-1B cap was reached (for both H-1B visa types)
- Visa applications were accepted on a rolling basis once the application season began, and USCIS allocated visas by lottery only for applications submitted on the date when the total number of applications received exceeded the remaining available slots
- They find that winning one additional H-1B visa worker crowds out approximately 1.5 otherwise available workers and does not increase patenting

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Doran, Gelber and Isen (2022)

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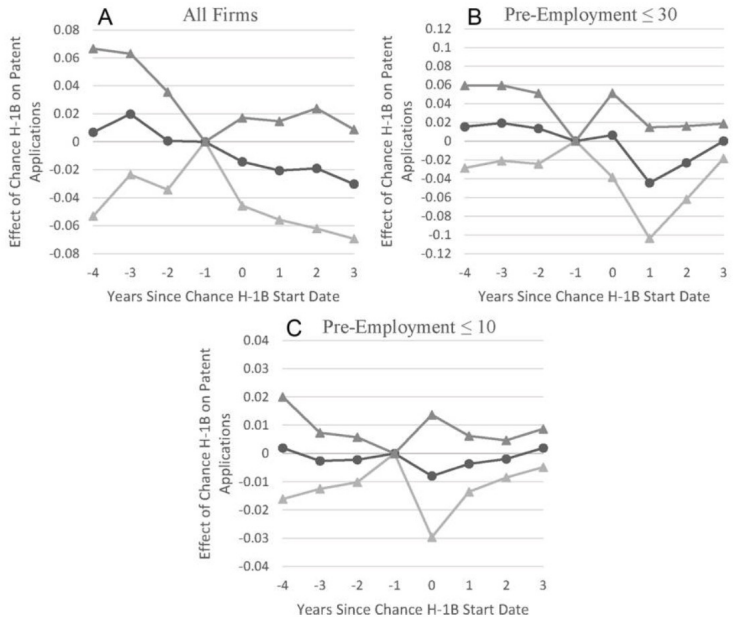

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Doran, Gelber and Isen (2022)

- DGI study estimates the effect of an additional H-1B visa to one firm on outcomes at that firm, holding constant H-1Bs given to other firms -> crowded-out workers may find employment elsewhere, and innovation could increase at other firms (suggested by authors and Bryan and Williams, 2021)
- Evidence of monopsony power – H-1Bs earn lower wages

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Non-Competes

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Monopsony in the labor market

- Growing acceptance that firms have some market power in wage setting
- Market power in wage setting arises when the labor supply to a firm is less than perfectly elastic
- In competitive market, firm faces same competitive price p for output (regardless of amt produced); pays a constant wage w to all workers (regardless of how many employed)

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Monopsony in the labor market

- A monopsonist no longer takes wages as given:
  - Faces an upward-sloping labor supply function
  - Pays lowest wage it can to hire required labor
  - Key assumption: can't pay workers different wages
  - Hiring an add'l worker requires raising wages for all workers
- Wages depend on labor employed: w(l), so hire cheapest workers first
- Can arise when there is a single dominant employer in an industry/area or when there are barriers that prevent working from changing employers easily (frictions)

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Non-Competes

- Non-compete agreements prevent former employees from accepting jobs with competitors – to protect trade secrets, customer confidentiality, or competitors from benefiting from specialized skills knowledge of employees
- Often they cannot work in the same industry
- Many point to the role of California law in the development of Silicon Valley, as CA prohibits post-employment non-compete covenants while Massachusetts has historically enforced them
- Marx et al show non-competes limit job mobility and lead to "career detours" (lower compensation for their level of experience)

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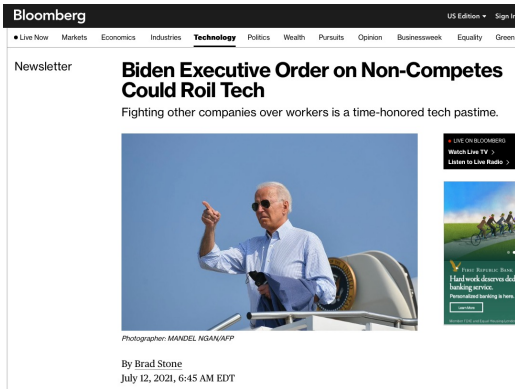
"Non-competes have played a key role in Silicon Valley lore. California rules make it difficult to prevent employees jumping ship. As a result, it's easier for workers to take insider know-how and best practices to other firms, or create new startups. The resulting innovation, some have argued, is the key difference that made the Bay Area into the world's tech Mecca instead of Massachusetts around the 1980s."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Newsletter

Biden Executive Order on Non-Competes Could Roil Tech

Fighting other companies over workers is a time-honored tech pastime.

Photographer: MANDEL NGAN/AFP

By Brad Stone
July 12, 2021, 6:45 AM EDT

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"New practices have emerged to facilitate employer collusion, such as CNC [covenants not to compete] clauses and no-raid pacts, but the basic insights are the same: employers often implicitly, and sometimes explicitly, act to prevent the forces of competition from enabling workers to earn what a competitive market would dictate, and from working where they would prefer to work."
- Alan Krueger "The Rigged Labor Market" (April 2017)

- CNCs increase the costs of moving so they can facilitate monopsony power by restricting worker mobility.
- But since workers voluntarily agree to CNC, could they be beneficial?

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Marx, Strumsky and Fleming (2009)

- Use reversal of non-compete enforcement policy in Michigan in 1985 as a natural experiment
- Use patent data to identify mobility
- Find lower mobility when non-competes are enforced, especially those with firm-specific skills and those who specialize in narrow technical fields

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Marx, Strumsky and Fleming (2009)

- In 1905 Michigan legislature passed statute 445.761 (similar to California's prohibition):

"All agreements and contracts by which any person…agrees not to engage in any avocation or employment…are hereby declared to be against public policy and illegal and void."

- This law governed non-compete enforcement until March 27, 1985, when the Michigan Antitrust Reform Act (MARA) repealed section 445 and with it the prohibition on enforcing non-compete agreements.

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Table 3 **Logit Models for Intrastate Employer Mobility of U.S. Inventors with at Least One Patent Prior to MARA in a Nonenforcing State**

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Michigan	−0.3713***	−0.2310***	−0.2747***	−0.3002***	−0.3289***	−0.3322***	−0.3418***	−0.3416***	−0.3416***	−0.3417***
	(0.07686)	(0.04985)	(0.04305)	(0.03941)	(0.03740)	(0.03612)	(0.03566)	(0.03565)	(0.03565)	(0.03565)
Postmara	−1.205766***	−1.2284***	−1.0586***	−0.4786***	−0.2606***	0.4787***	0.5156***	0.4528	1.1094	−0.3505
	(0.0804)	(0.07596)	(0.07402)	(0.06101)	(0.07446)	(0.08194)	(0.1433)	(0.3731)	(1.0197)	(1.1552)
MI * postmara	−0.3381	−0.3654***	−0.2207**	−0.2204***	−0.2026***	−0.1616**	−0.1176*	−0.07585	−0.03967	−0.01716
	(0.2338)	(0.09604)	(0.07078)	(0.06144)	(0.05627)	(0.05248)	(0.04959)	(0.04736)	(0.04611)	(0.04615)
Constant	−1.7183***	−1.5878***	−1.6847***	−2.0236***	−2.2094***	−2.6507***	−2.4877***	−2.3846***	−3.2025**	−1.3235
	(0.03379)	(0.02855)	(0.03088)	(0.03758)	(0.04561)	(0.07116)	(0.1377)	(0.3709)	(1.0177)	(1.1082)
+-year window	1	3	5	7	9	11	13	15	17	All years
No. of observations	22,076	63,206	102,635	140,903	178,795	214,909	241,107	256,422	268,945	274,406

Notes. The "+-year window" indicates how many years of data on either side of the reform were included in that particular regression (e.g., a value of 15 indicates that patents from 1970 to 2000 were included). All models include annual indicators.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

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Other evidence

- Balasubramanian et al examine impact of covenants not to compete (CNCs) on employee mobility and wages
- Draw on a 2015 CNC ban for technology workers in Hawaii
- Results are consistent with CNC enforceability increasing monopsony power as the ban increased mobility by 11% and new-hire wages by 4%

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Empirical Research in Labor & Innovation

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R. Freeman's 5 Rules for Empirical Work in Labor Economics

1) Create your own variation through an experiment (field or laboratory) or study markets when they experience sufficiently sharp exogenous shocks to create "natural experiments" or learn the institutional details of markets to find plausible sources of variation (policy shifts and institutional quirks)

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R. Freeman's 5 Rules for Empirical Work in Labor Economics

2) Focus on fundamental first-order economic and behavioral principles (supply and demand; incentives; altruism and reciprocity)
3) Probe the robustness of empirical findings with different data sets, different specifications, and across time and space – tension vs. pre-analysis plans, pre-specification and concerns with data mining

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R. Freeman's 5 Rules for Empirical Work in Labor Economics

4) Don't be satisfied with just standard and easily available data sets – be willing to do your own survey research, use the resources of the web to collect data (eBay; on-line newspaper archives; on-line school or arrest record data); or to work with relevant organizations to collect/gain access to administrative data (IRS tax records, matched employer-employee data, Scandinavian matched registry data, Social Security admin data, personnel data, …)

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R. Freeman's 5 Rules for Empirical Work in Labor Economics

5) Discuss issues and analyses with the participants in the markets under study – 'In a field lacking decisive tests of hypotheses, it is worth listening to what eyewitnesses and participants have to say' ("quarks can't speak" but humans can tell you what they think is going on!)

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