Faculty hiring and the spread of scientific ideas

Allison Morgan, Dimitrios Economou, Samuel Way, Aaron Clauset

Building Better Epistemic Networks Workshop, Sept 5th 2019

Goals for this talk:

1. Quantify prestige in academia
2. Identify a structural mechanism for how prestige affects research progress
3. Discuss implications

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Academic workforce

https://en.wikipedia.org/wiki/Solvay_Conference

Trajectories of individuals form a network

MS, Computer Science
University of Colorado

BA, Physics
Reed College

PhD, Computer Science
University of Colorado (🤞)

PhD, Computer Science
University of New Mexico

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BS, Physics
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Faculty hiring networks

Each directed edge $u \rightarrow v$
PhD from $u \rightarrow$ faculty at v

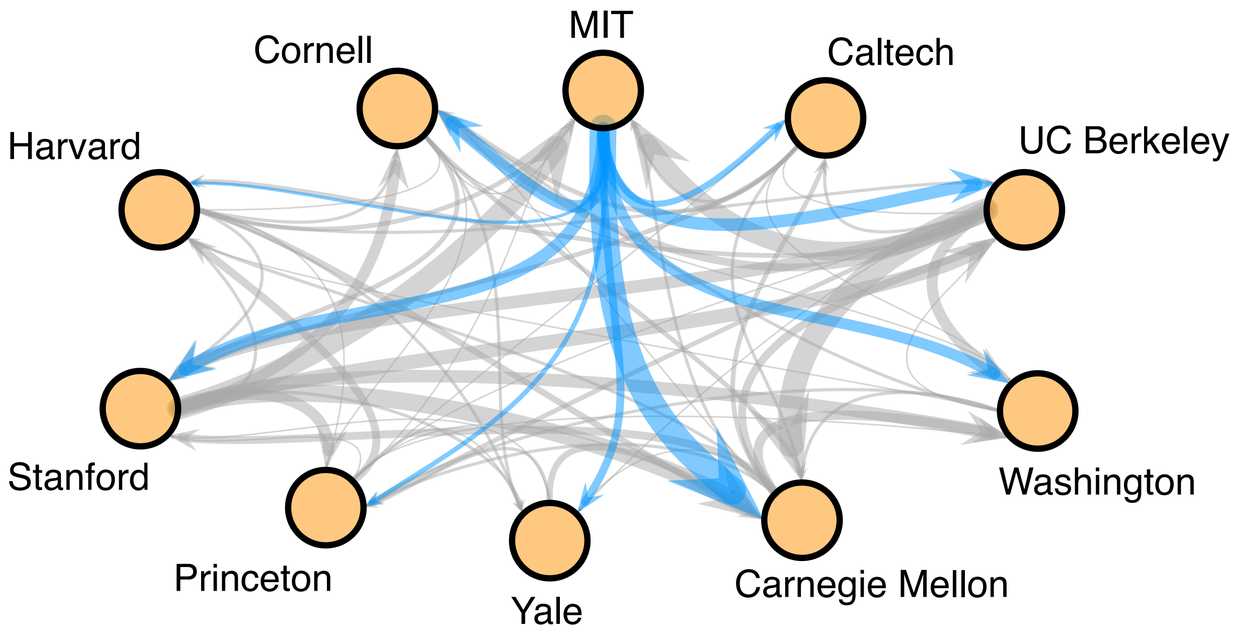
[US academia: big, mobile, self-contained, competitive]

Dramatic inequality in PhD production [80/20 rule holds]

Common large-scale structure: influential, well-connected core

Small percentage of edges are self-loops [8% in CS]

Assumption: reveals collective preferences. Hiring committees want to hire the best candidates



Computer science faculty hiring network;
http://tuvalu.santafe.edu/~aaronc/facultyhiring/

Quantifying prestige

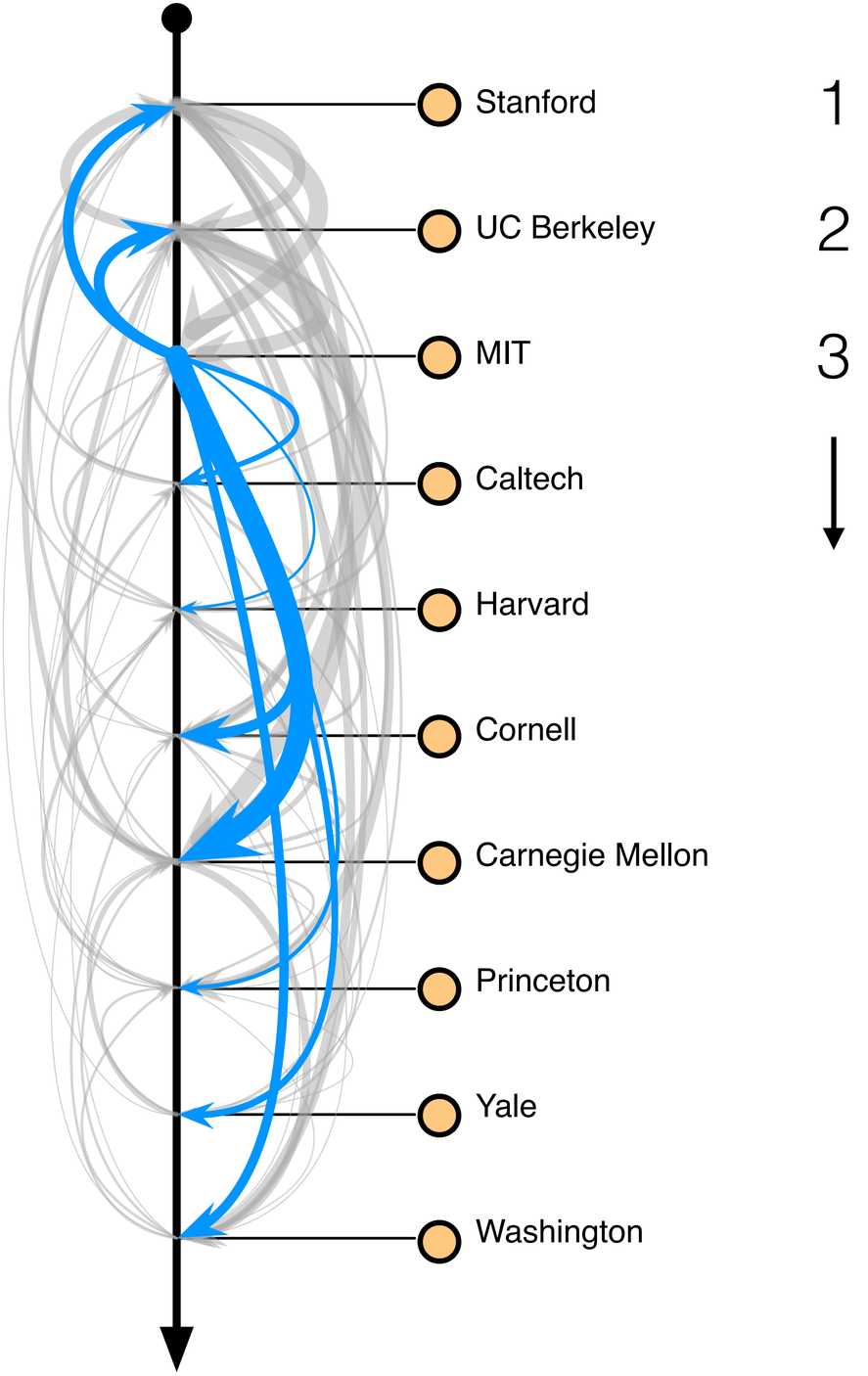
Many rankings exist:

U.S. News & World Report, National Research Council, Princeton Review [U.S.] …

But they often describe the inputs to the system, or don't reflect what universities truly think of each other.

Let's construct a ranking based on revealed university preferences through hiring.

https://en.wikipedia.org/wiki/College_and_university_rankings



Quantifying prestige

Compute an average **Minimum Violation Rank** (MVR) to find an order of nodes (universities) that minimizes "upsets."

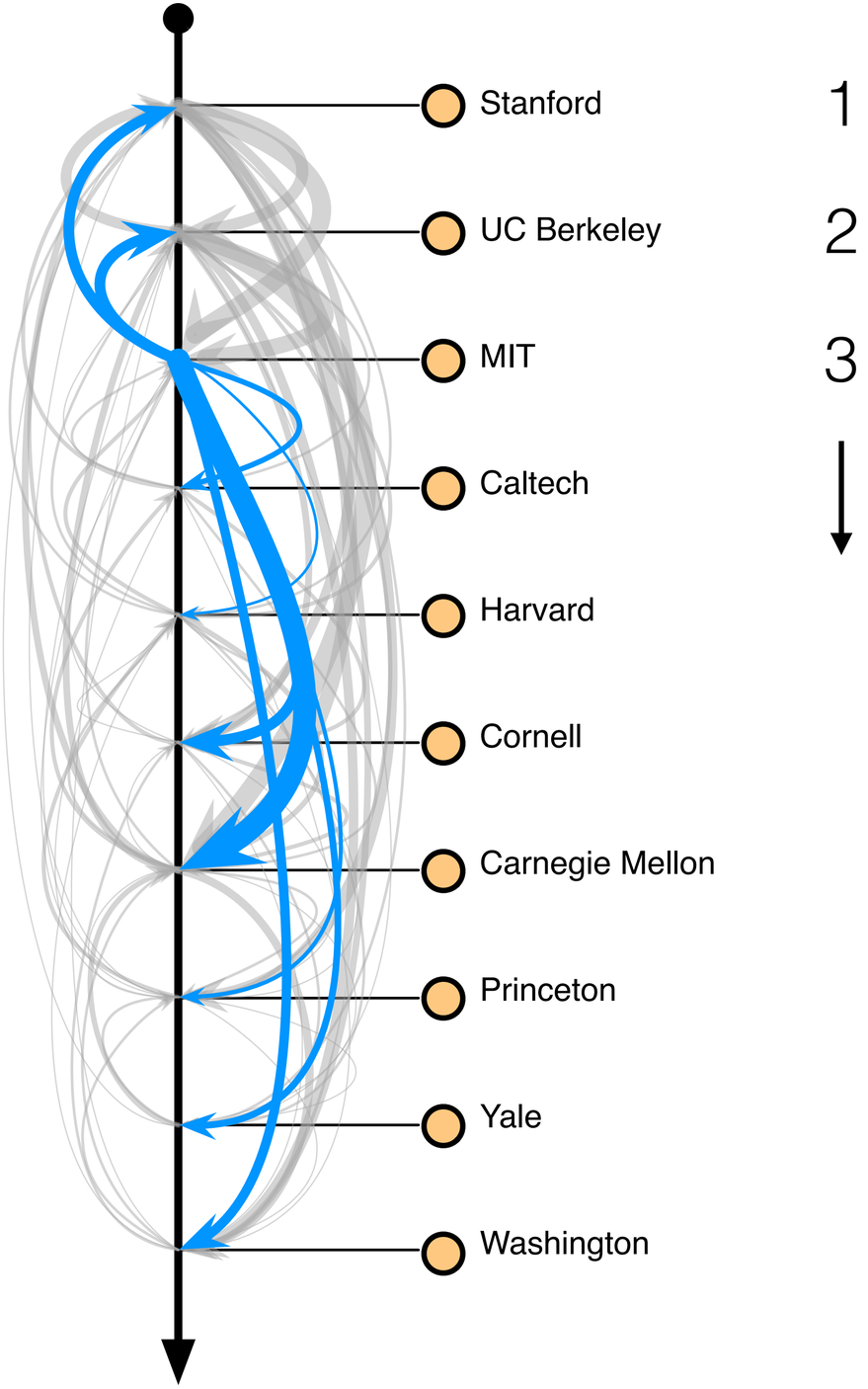
Select permutation (a ranking) π that minimizes the number of "rank violations": edges (u, v) where $\pi_v < \pi_u$

Higher-ranked universities have greater placement power.

Systematic inequality and hierarchy in faculty hiring networks

Aaron Clauset,[1,2,3]* Samuel Arbesman,[4] Daniel B. Larremore[5,6]

Science Advances 1(1), e1400005 (2015)



Aside: Application of prestige

We can use these rankings to generate predictions for individuals and the system.

Gender, Productivity, and Prestige in Computer Science Faculty Hiring Networks

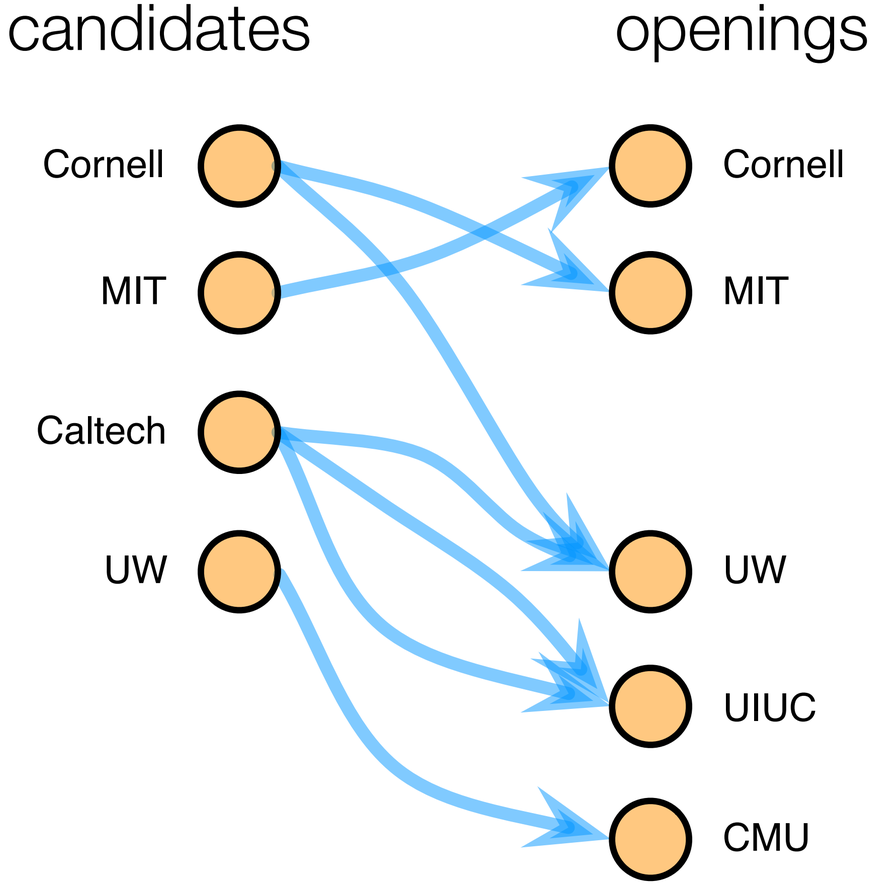
Samuel F. Way,[1,*] Daniel B. Larremore,[2,†] and Aaron Clauset[1,3,2,‡]

Proc. 25th Int'l World Wide Web Conf. (2016)

Consider the annual matching process of candidates to openings.

Each year t, has $\{u_t\}$ candidate "stubs" and $\{v\}_t$ opening "stubs."

Given a pair (u_i, v), the probability of matching depends on that pair's features $x[u_i, v]$.



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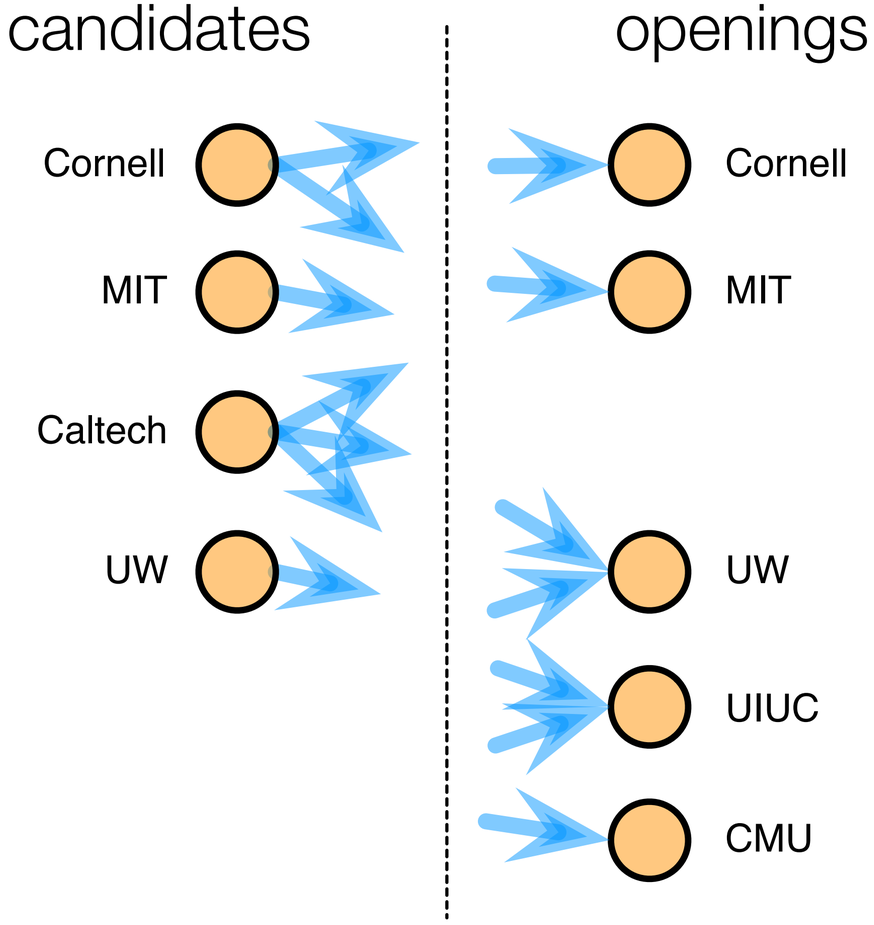

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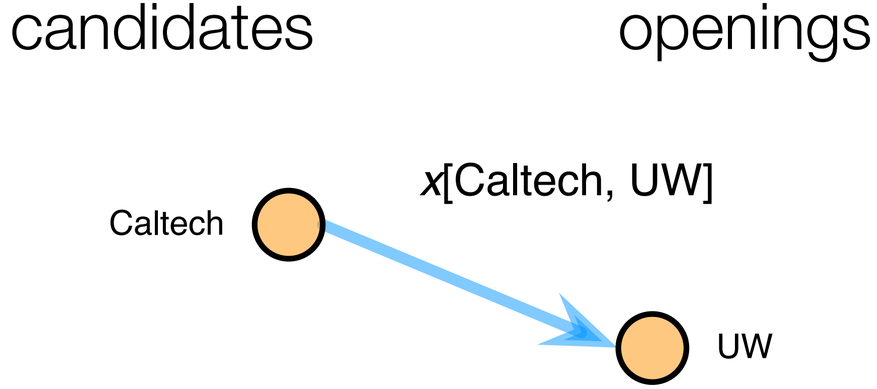

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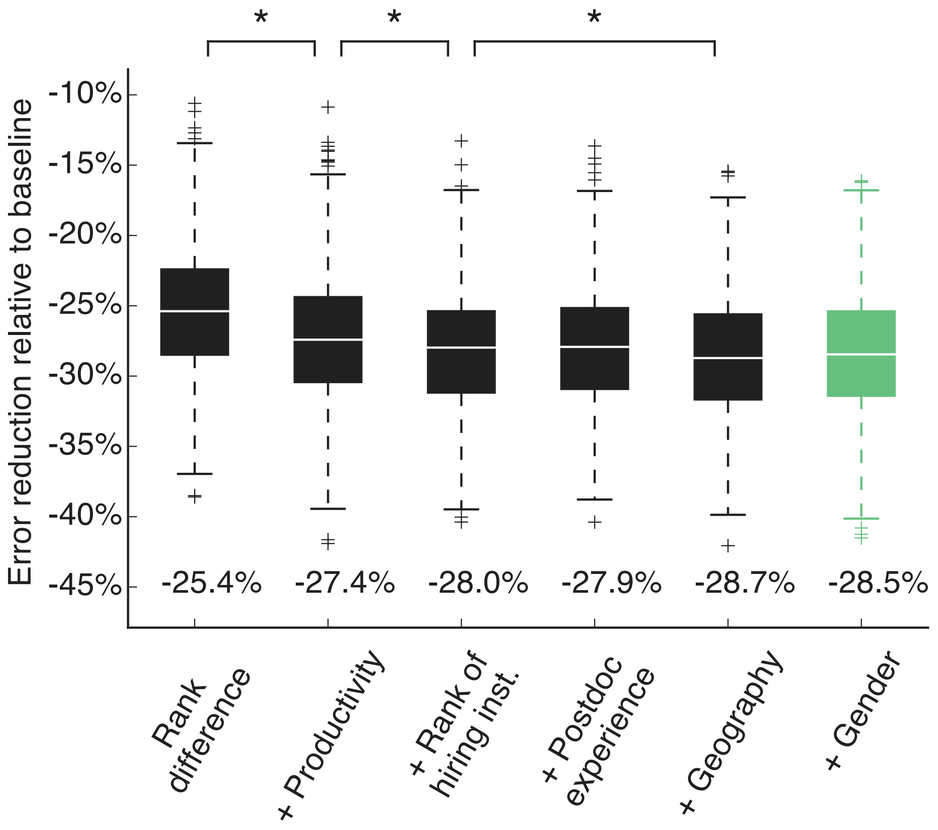
The most important modeling features are **differences in prestige** and productivity.



Features of hierarchy

systematic

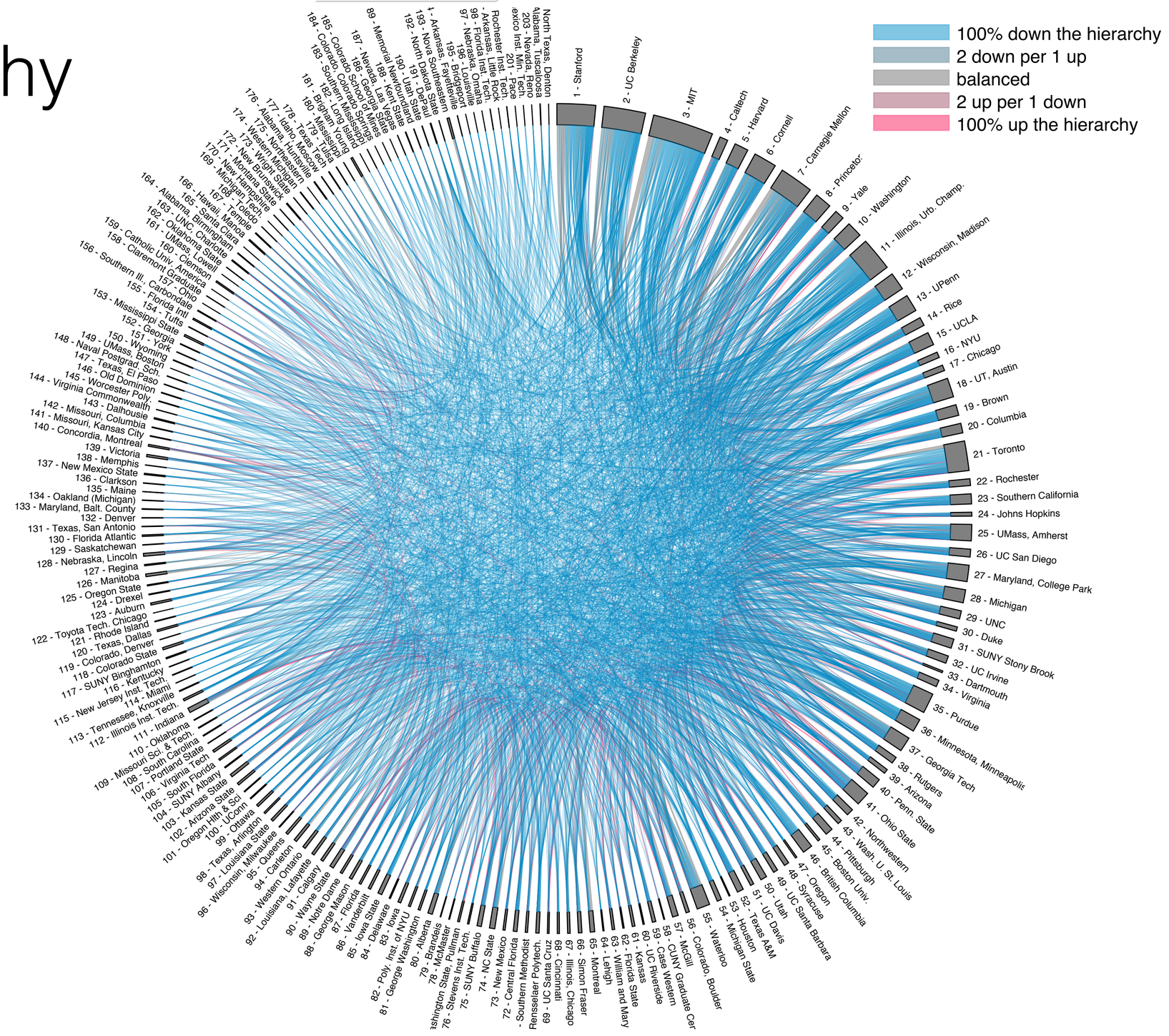
90% of hiring movement
is “down” the hierarchy

steep

< 7% of faculty have PhD
from lower 75% of universities

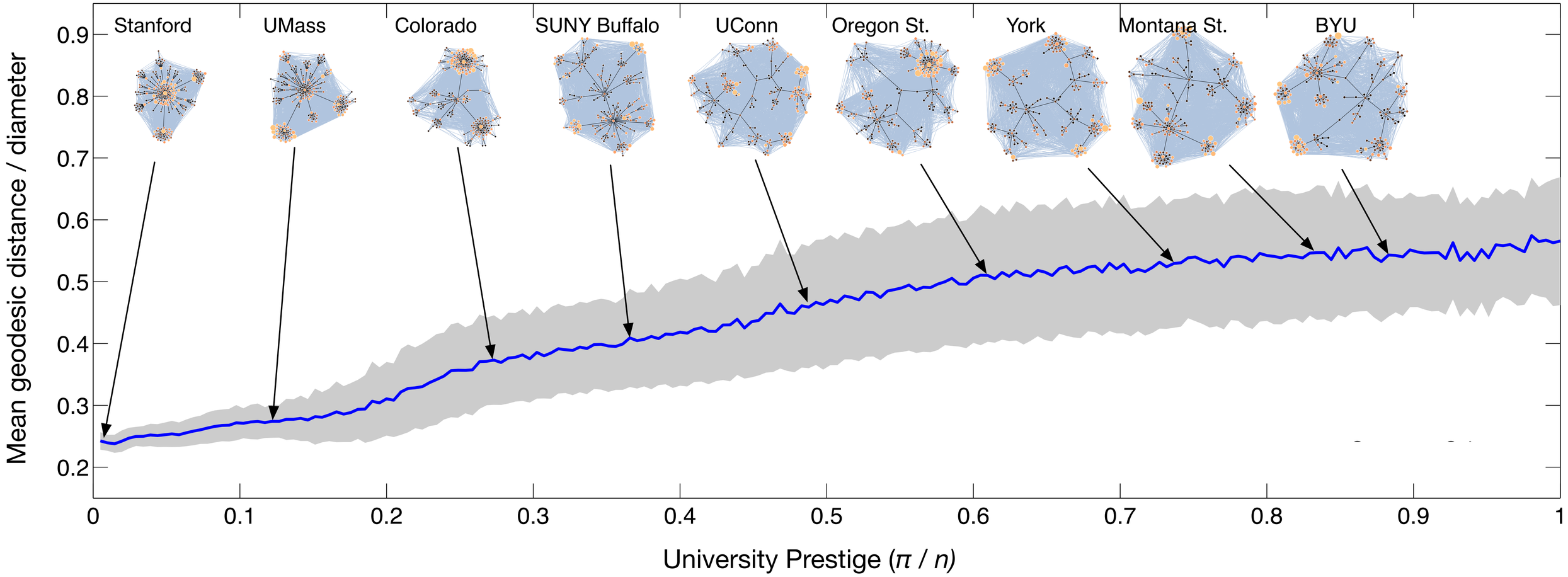
biased

median change for women
~3 ranks worse than men



http://danlarremore.com/faculty/
Explore the data for History, CS, Business

Core-periphery position changes with rank

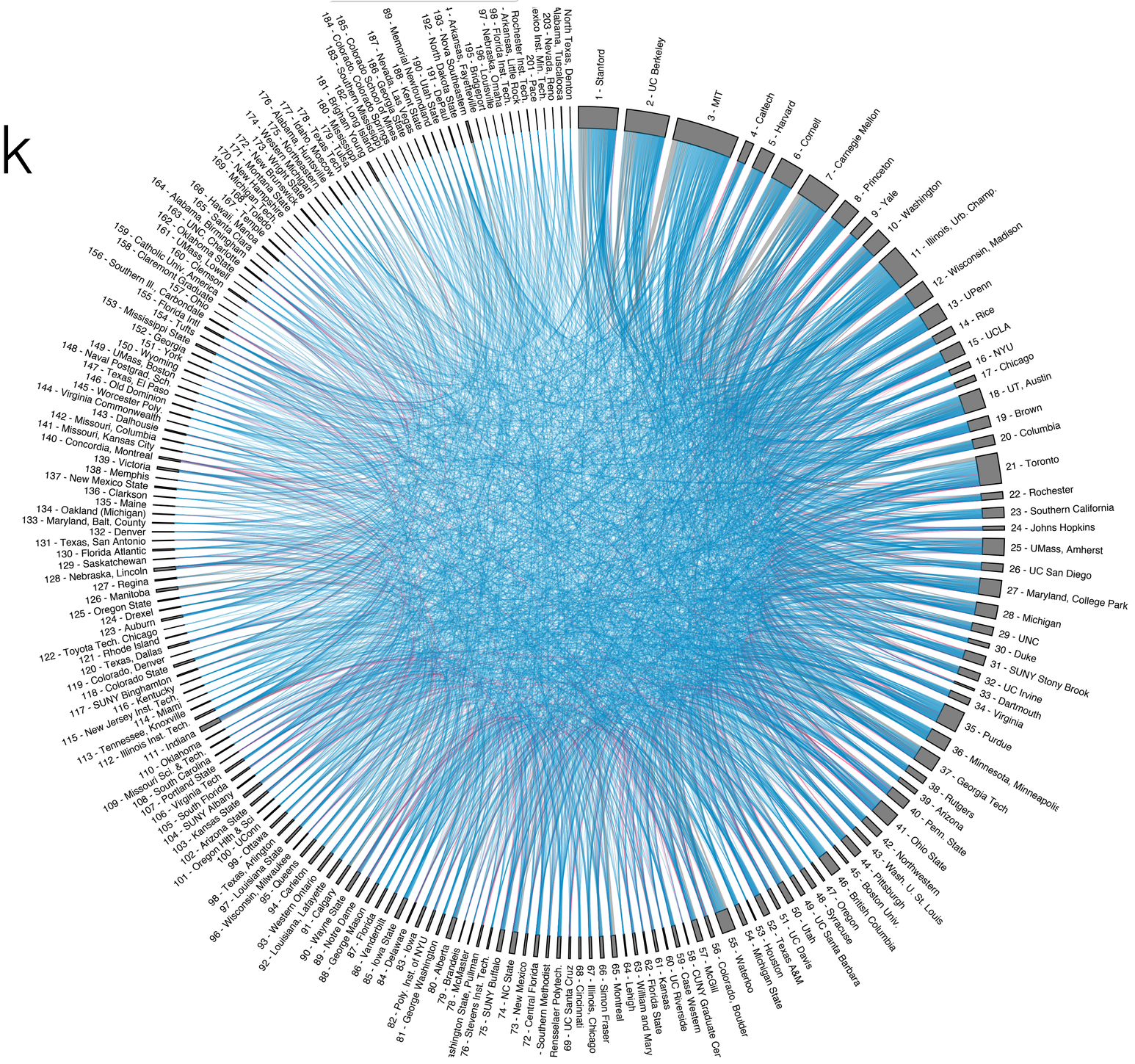


What are the implications?

Shape of the faculty hiring network

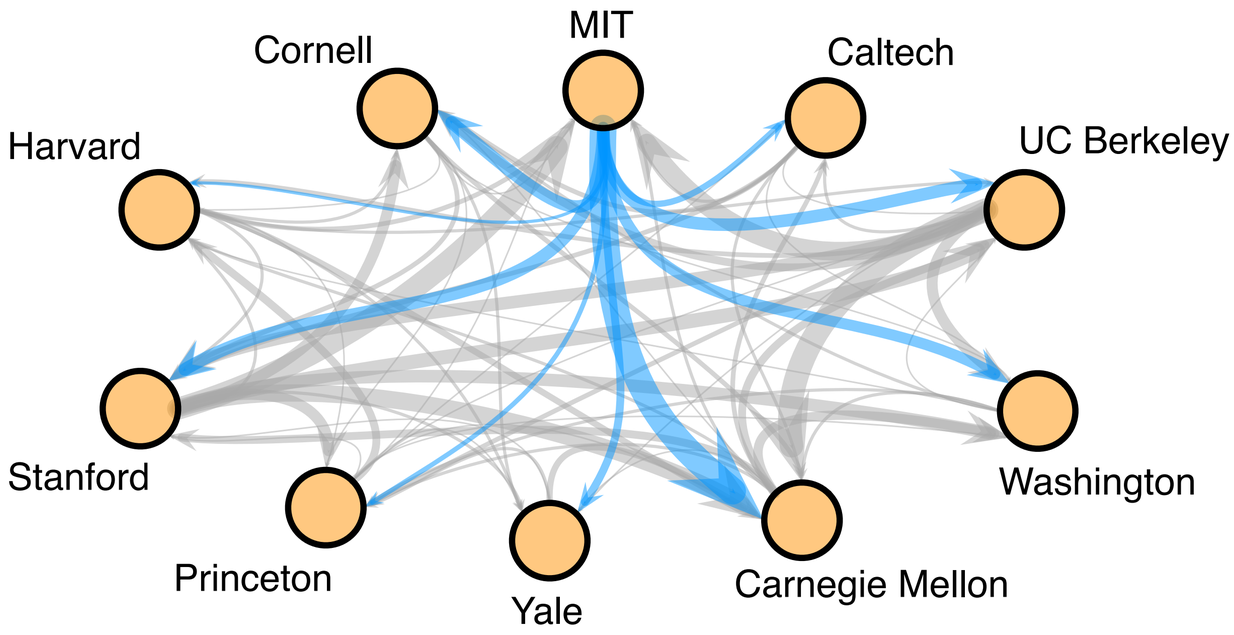
Universities in the core are (obviously) very close to all other core universities.

Next: core position enables substantial influence over research **agendas**, research **communities**, and departmental **norms** throughout a discipline.



Shape of the faculty hiring network

- Large inequalities in placement power
- Faculty flow out of core, into periphery
- Modest fraction stays inside core
- Small fraction flows “upstream”
- Prestige describes influence via individuals placement
- **Next:** How does prestige affect science as a system?



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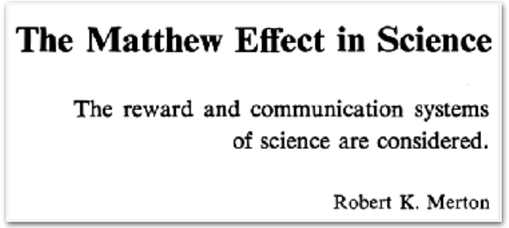
Science is a meritocracy

https://pxhere.com/en/photo/950021 *(CC 2.0)*

Science is a meritocracy… right?

https://pxhere.com/en/photo/950021 *(CC 2.0)*

Some scientists and institutions are far more influential than others


The Matthew Effect in Science

The reward and communication systems of science are considered.

Robert K. Merton

Science 159.3810, 56-63 (1968)


Reputation and impact in academic careers

Alexander Michael Petersen[a,1], Santo Fortunato[b,1], Raj K. Pan[b], Kimmo Kaski[b], Orion Penner[c], Armando Rungi[a], Massimo Riccaboni[c,d], H. Eugene Stanley[e,1], and Fabio Pammolli[a,e]

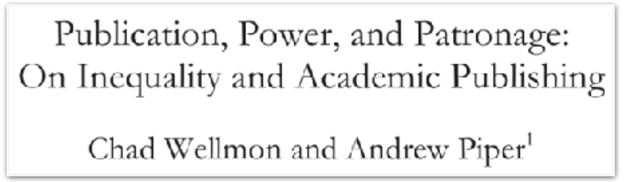
Proc. Natl. Acad. Sci. U.S.A 111(43) 15316-15321(2014)


DEPARTMENTAL EFFECTS ON SCIENTIFIC PRODUCTIVITY*

PAUL D. ALLISON
University of Pennsylvania

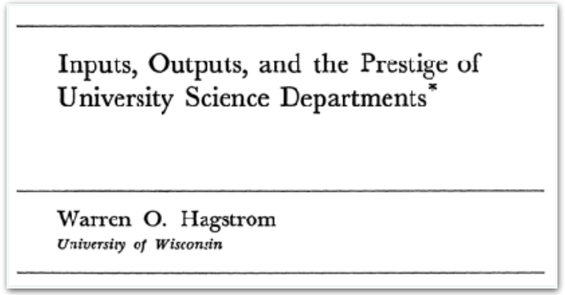
J. SCOTT LONG
Indiana University

Am. Soc. Rev. 55, 469-478 (1990)


Publication, Power, and Patronage: On Inequality and Academic Publishing

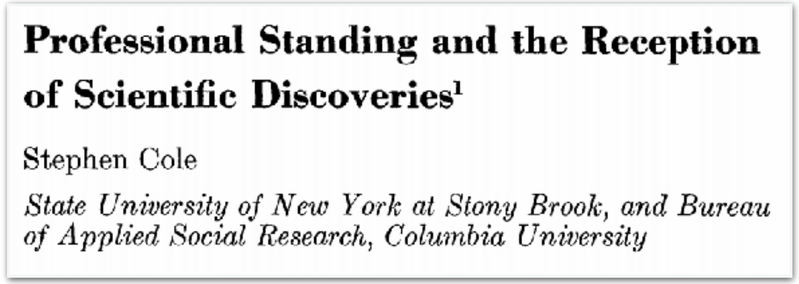
Chad Wellmon and Andrew Piper[1]

Critical Inquiry (2017)


Inputs, Outputs, and the Prestige of University Science Departments*

Warren O. Hagstrom
University of Wisconsin

Sociol. Educ. 375-397 (1971)


Professional Standing and the Reception of Scientific Discoveries[1]

Stephen Cole

State University of New York at Stony Brook, and Bureau of Applied Social Research, Columbia University

Am. J. Soc. 76(2), 286-306 (1970)

Three explanations

(1) genuine differences in merit

(2) non-meritocratic social processes

(3) non-meritocratic structural factors

https://www.olympic.org/news/1932-the-podium-makes-its-olympic-debut

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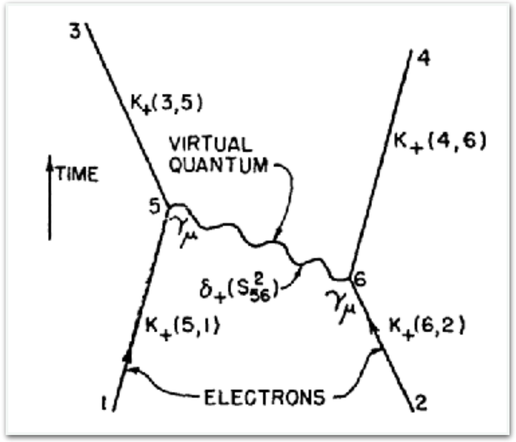
Earliest published Feynman Diagram



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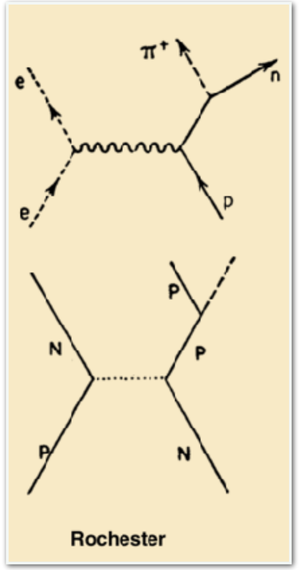

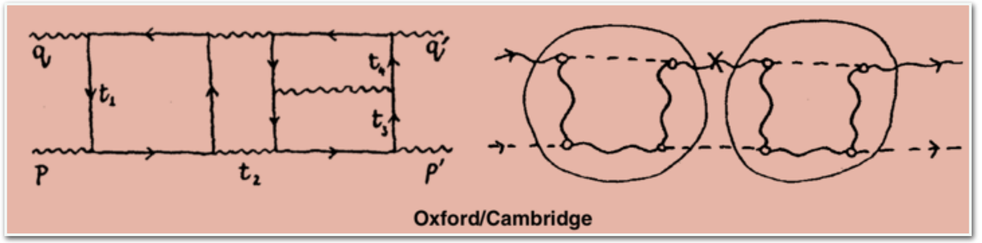

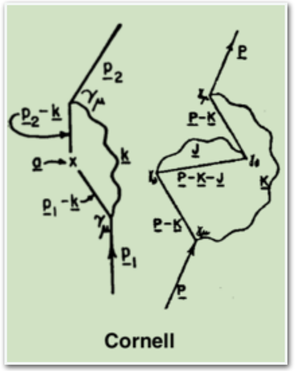

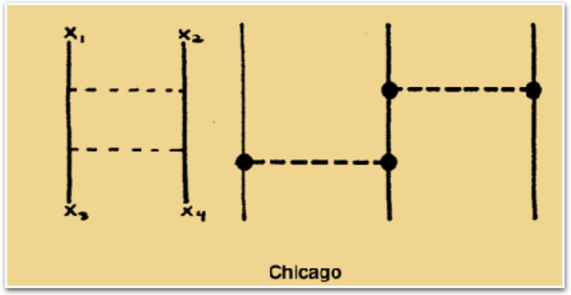

American Scientist 55, 156-165 (2005)

Proc. 11th Conf. on Web and Social Media (2017)

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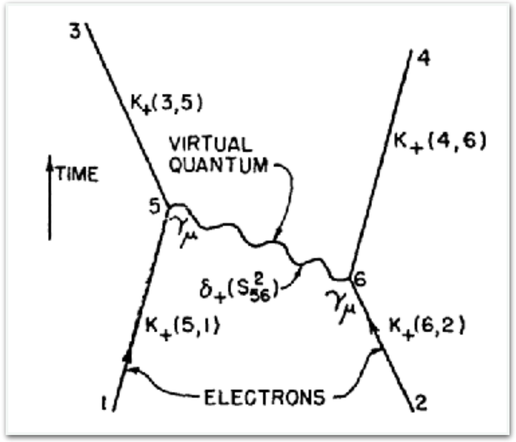

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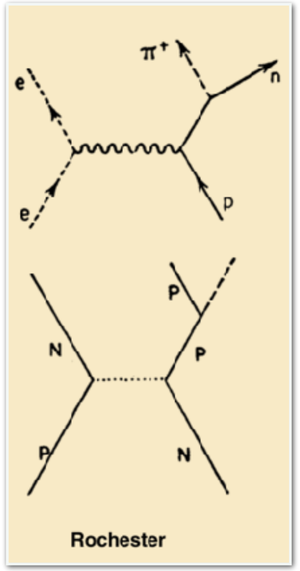

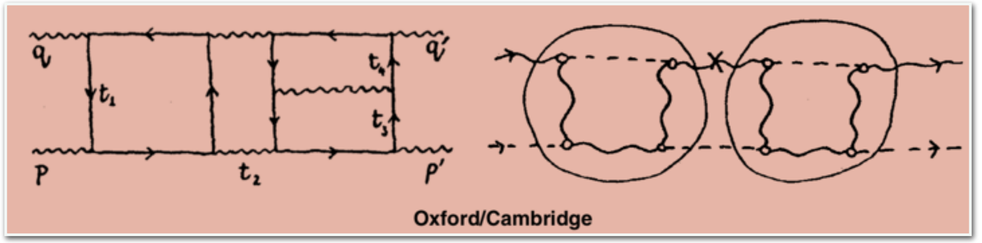

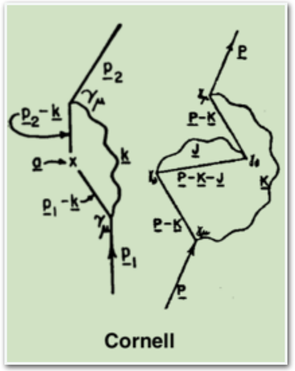

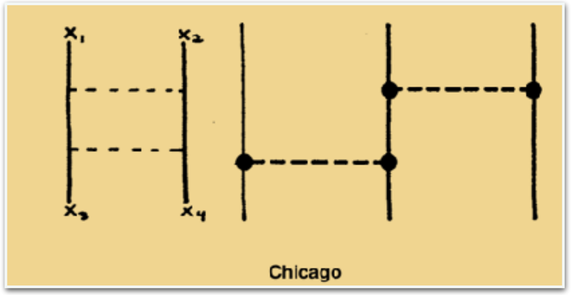

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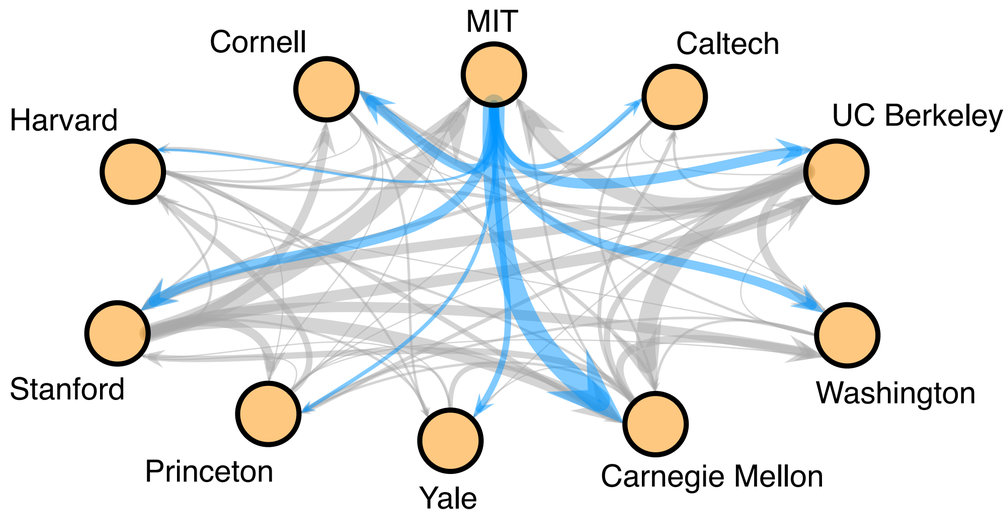

Sci. Adv. 1(1), e1400005, 2015.

Data

Education & employment for 4,388 faculty from 205 U.S. and Canadian CS departments employed between 2011-2012

- Institution (node) *u* with unique prestige *π*
- Edge (*u, v*) represents a single PhD candidate from *u* who got an assistant faculty position at *v*

Over 2M publication records for tenure-track faculty.

- Title, author list, venue, and date
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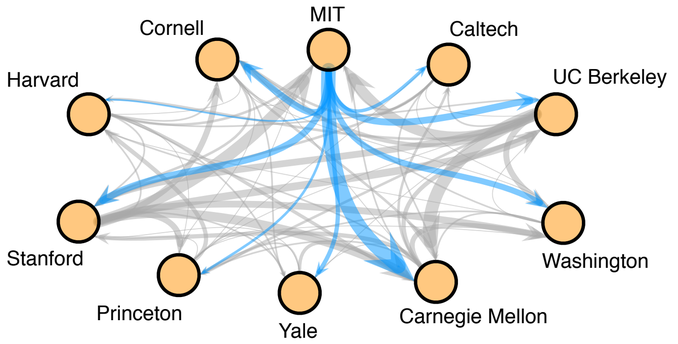
Faculty hiring networks



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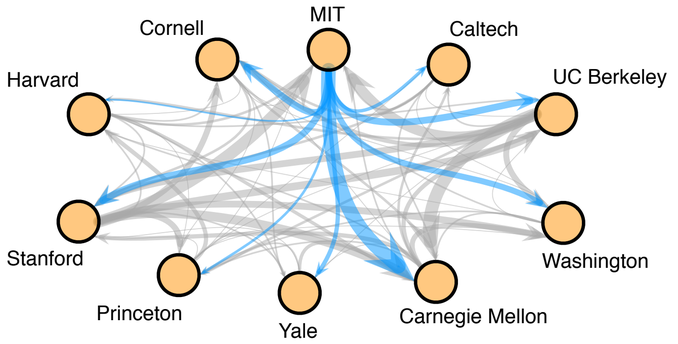

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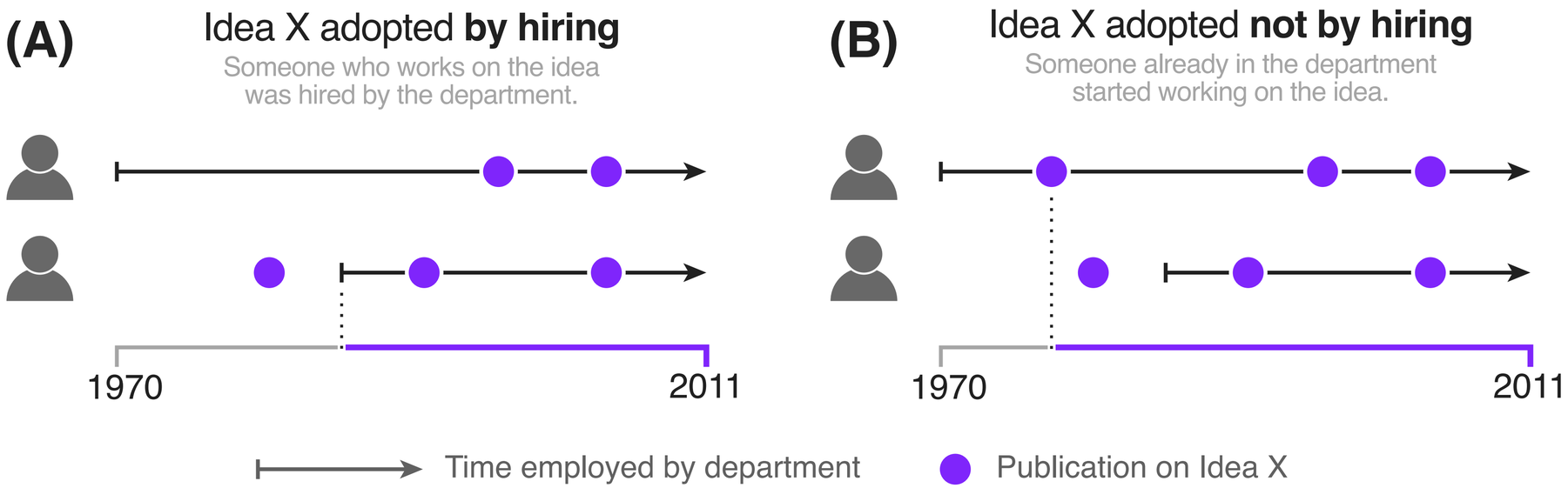
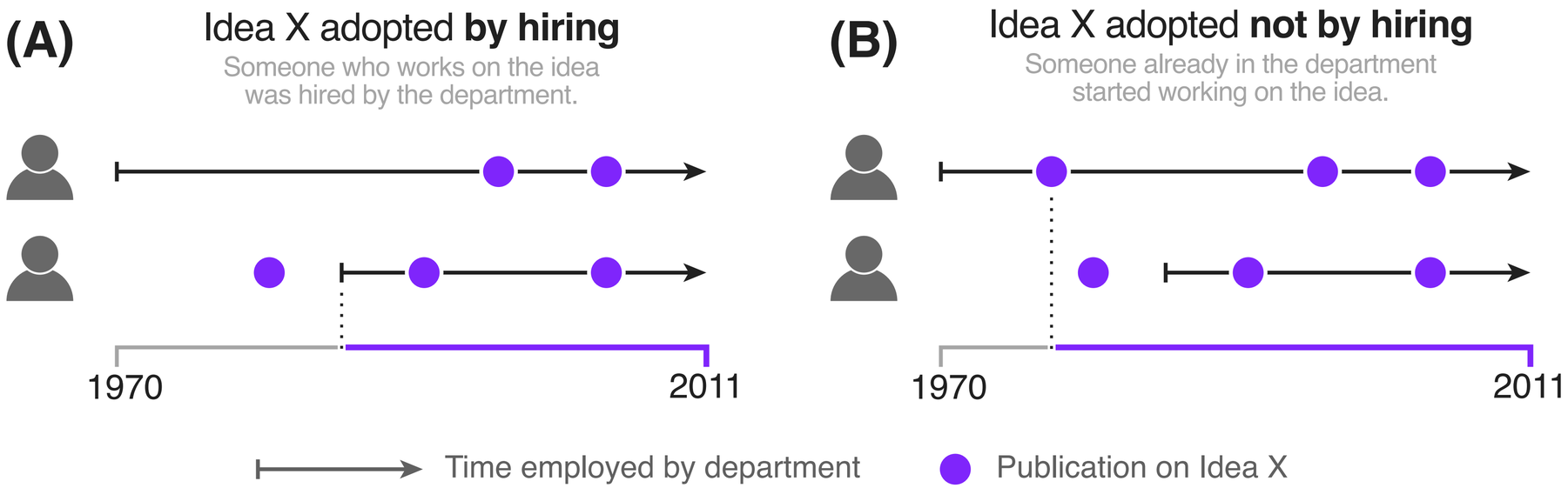


R1: Are research ideas carried by faculty hiring?

Test: choose five research topics and evaluate the fraction of times those topics spread via (A) in real life, compared to the expected fraction under a permutation of publication titles



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Recover 241 spreading events for the five topics, each affecting between 11-58% of departments

- 88 (37%) of these happen by way of hiring
  - 71 (81%) of those, move via from high to low prestige universities

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Research Areas	
topic modeling	✅
incremental computing	✅
quantum computation	✅
mechanism design	✅
deep learning	❌

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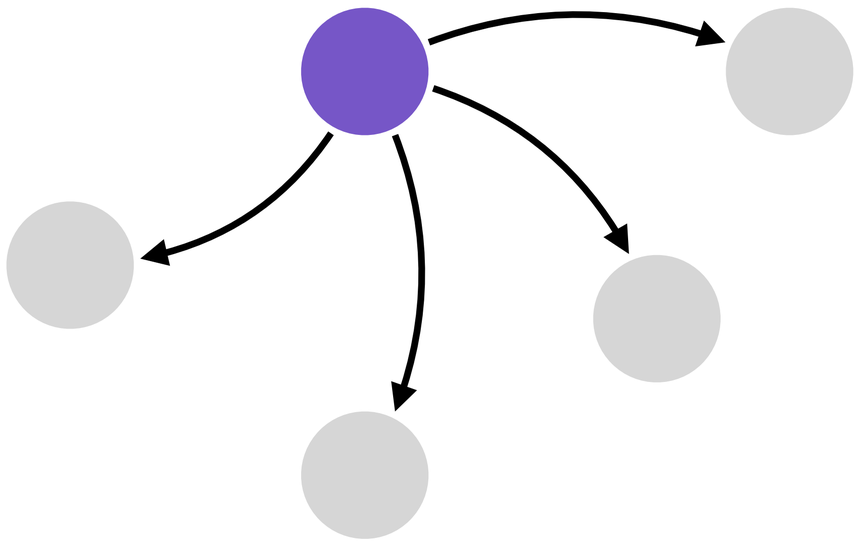
Faculty hiring acts as a mechanism for the spread of ideas, with differential effects by topic, across the computer science community

R2: Does the structure of the faculty hiring network affect the spread of ideas?

To simulate the diffusion of ideas, use a **Susceptible-Infected** (SI) model.



Seed an epidemic at a university with unique prestige π, varying the transmissibility p (quality of an idea)

Quality of idea relates to how many nodes will adopt an idea (on average)

Measure the fraction of universities which adopted the idea

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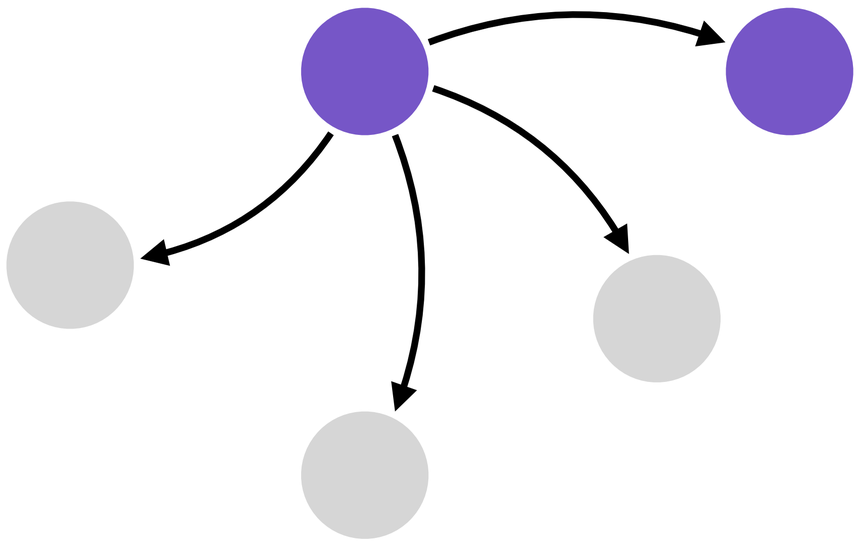

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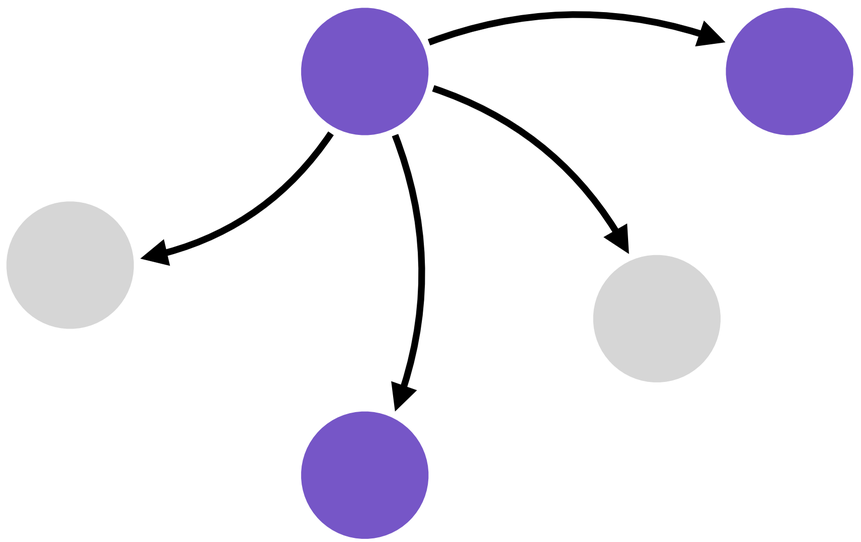

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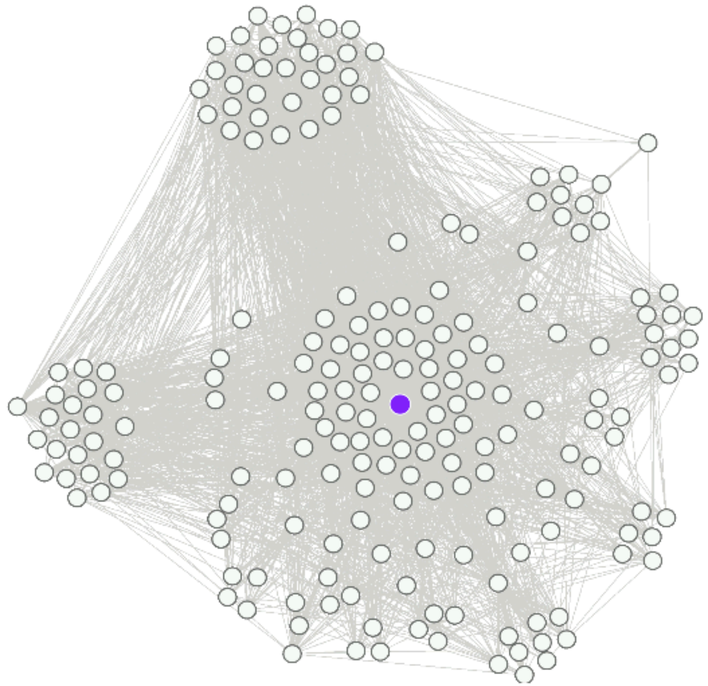
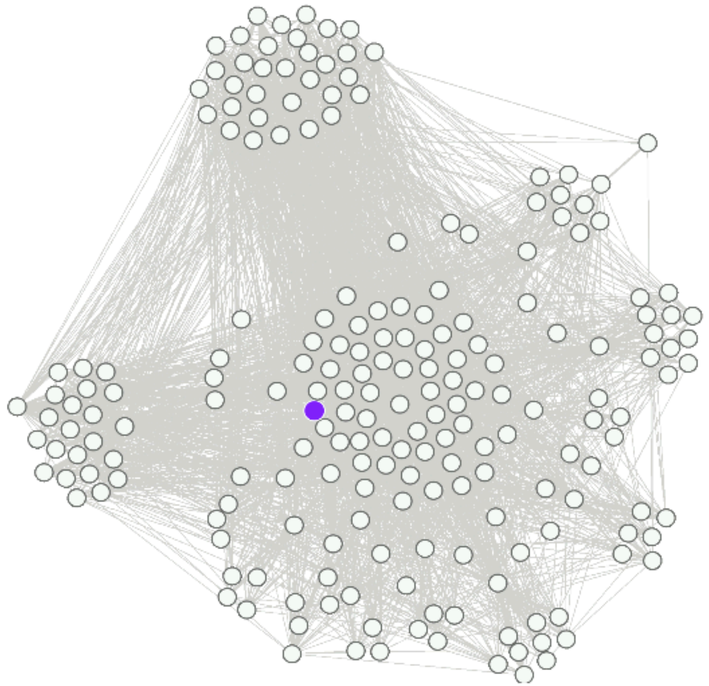
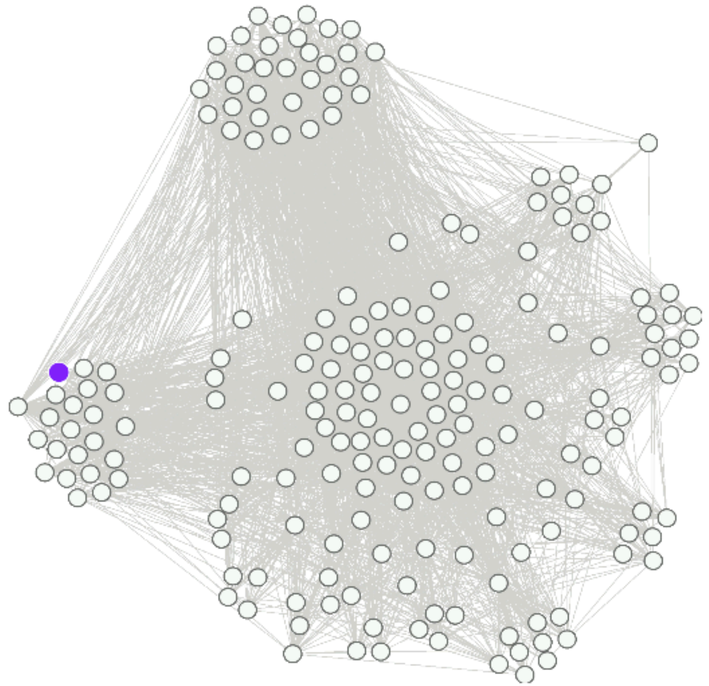
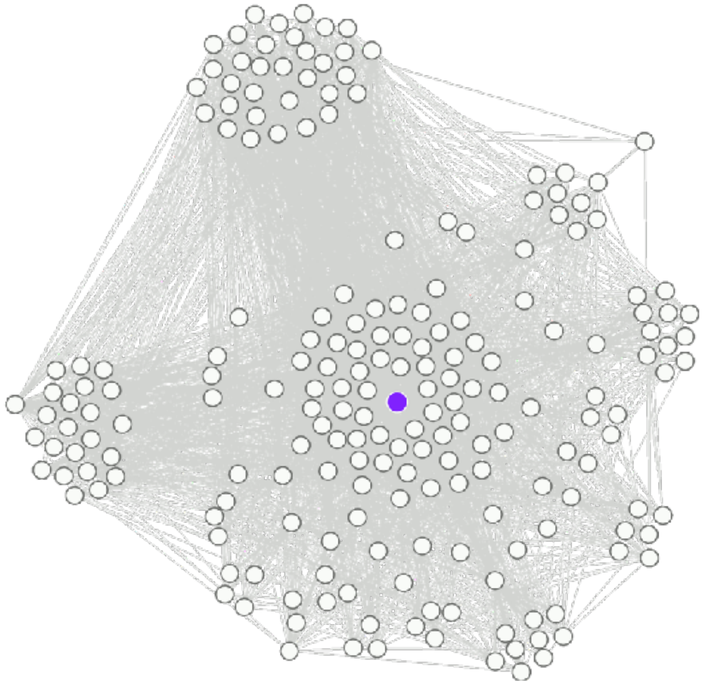




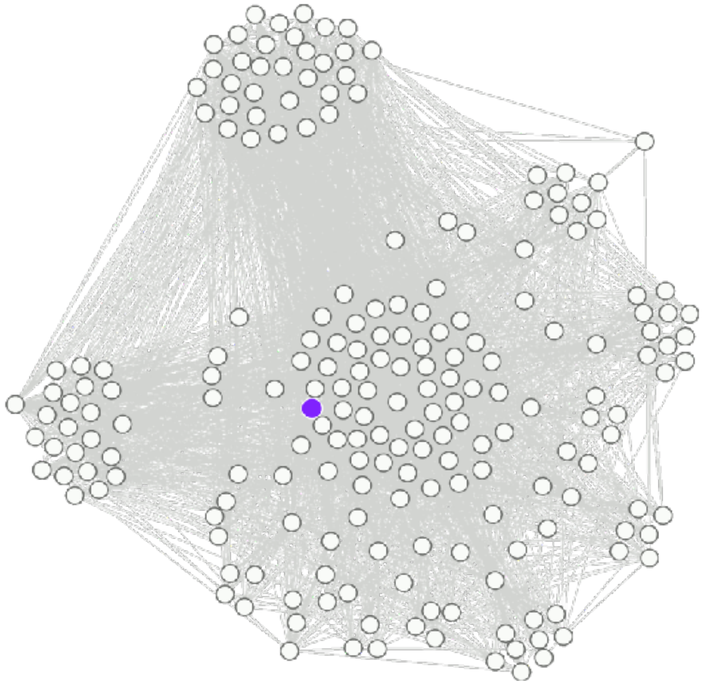


Remember: Core-periphery position changes with prestige

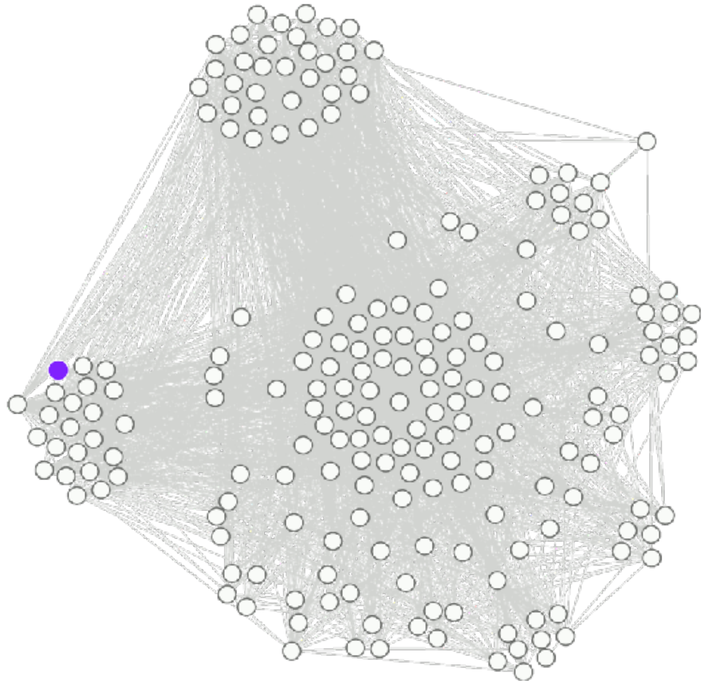
R2: Does the structure of the faculty hiring network affect the spread of ideas?



High Prestige (π = 2.23)



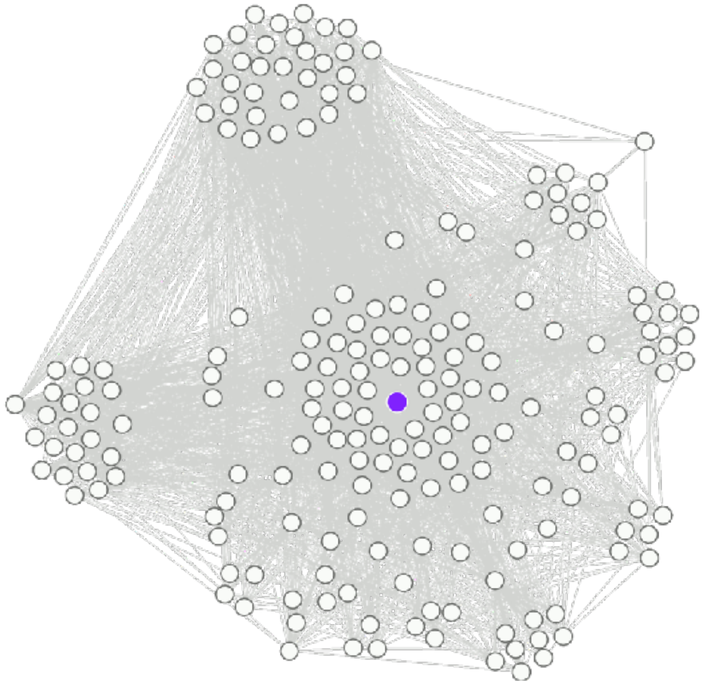
Medium Prestige (π = 68.17)



Low Prestige (π = 130.66)

Explore more simulations
https://pikawolfy.github.io/epistemicInequality/

R2: Does the structure of the faculty hiring network affect the spread of ideas?



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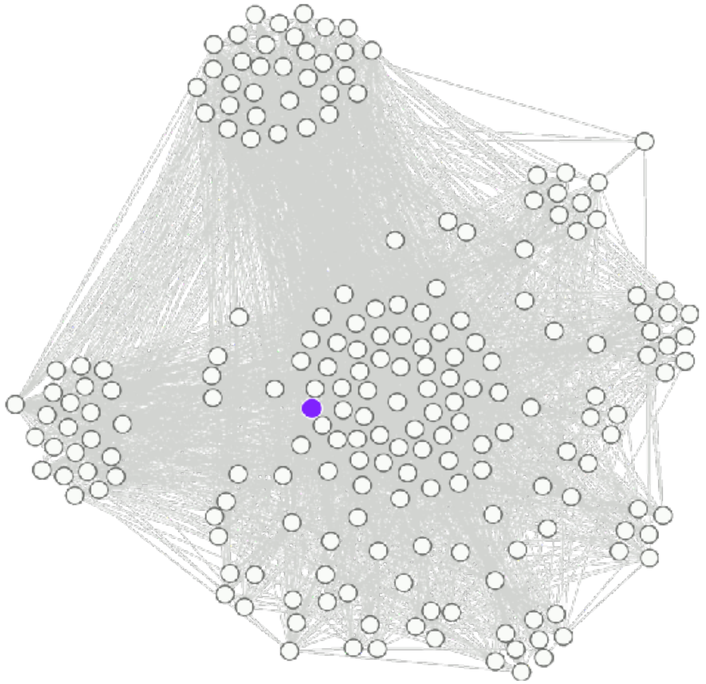

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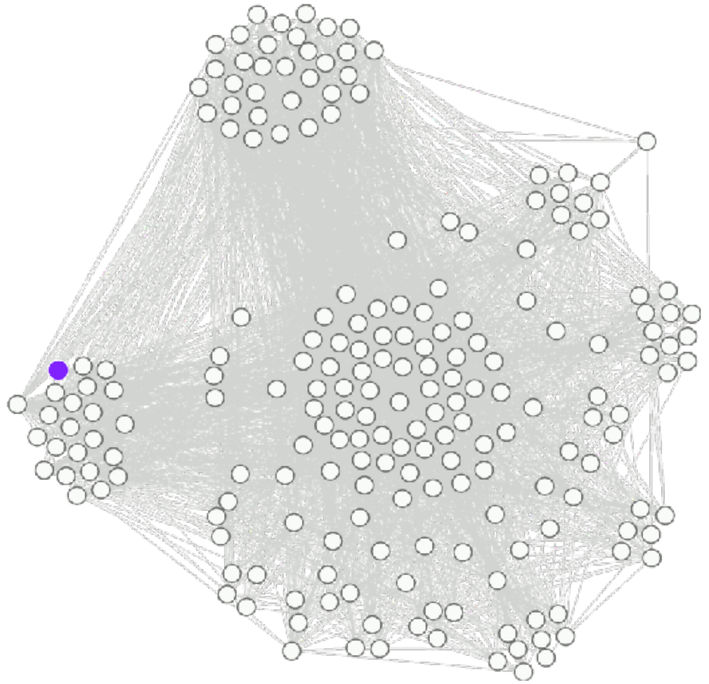

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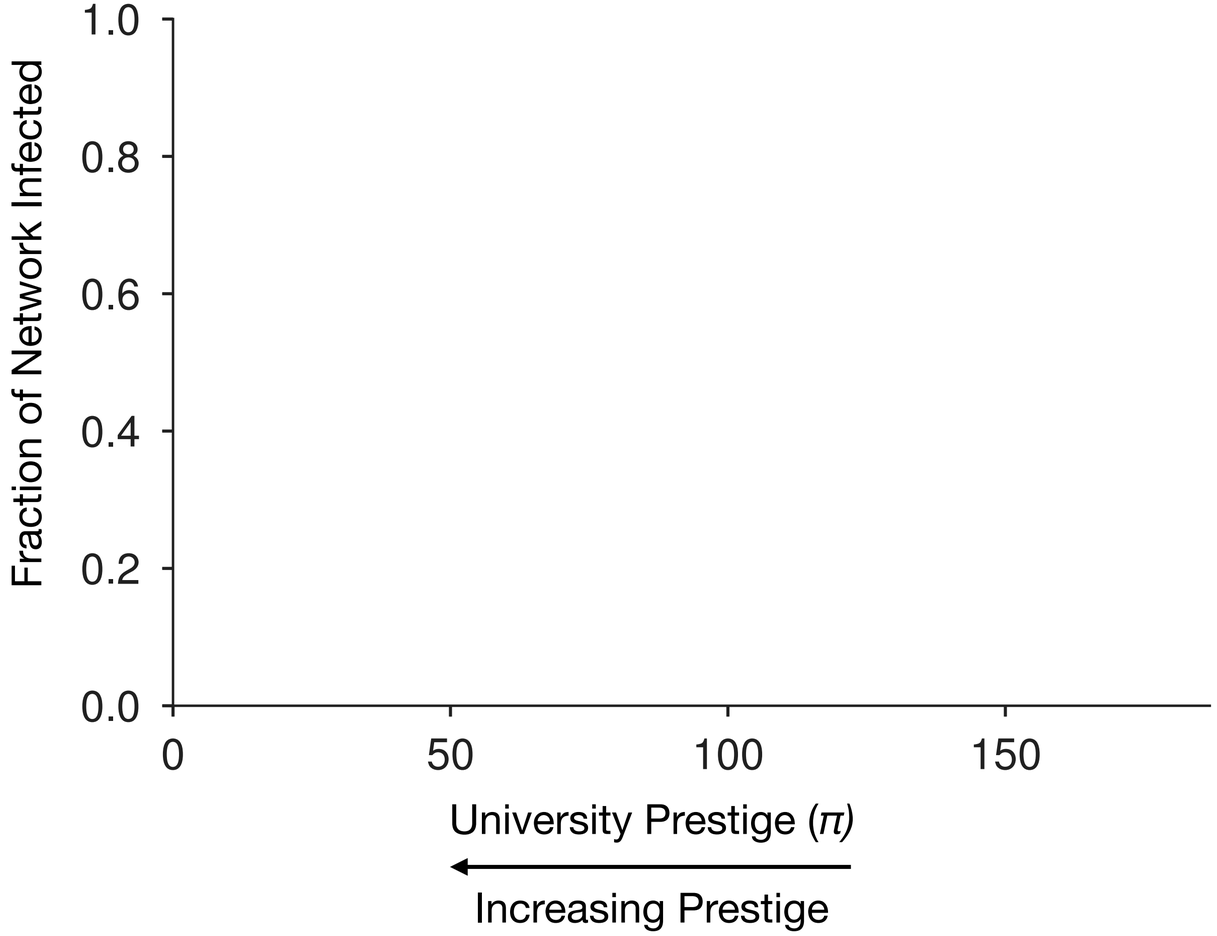

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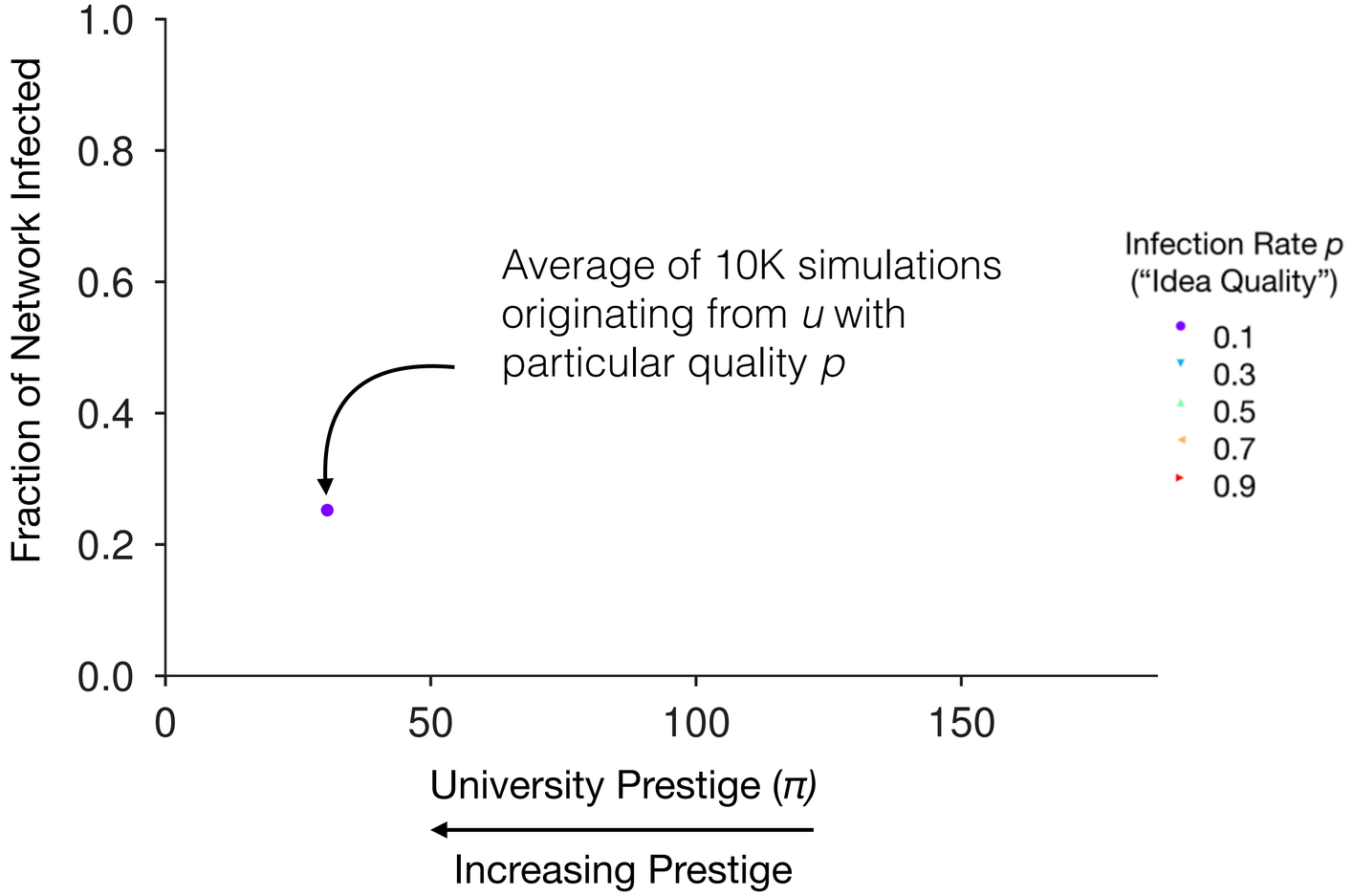

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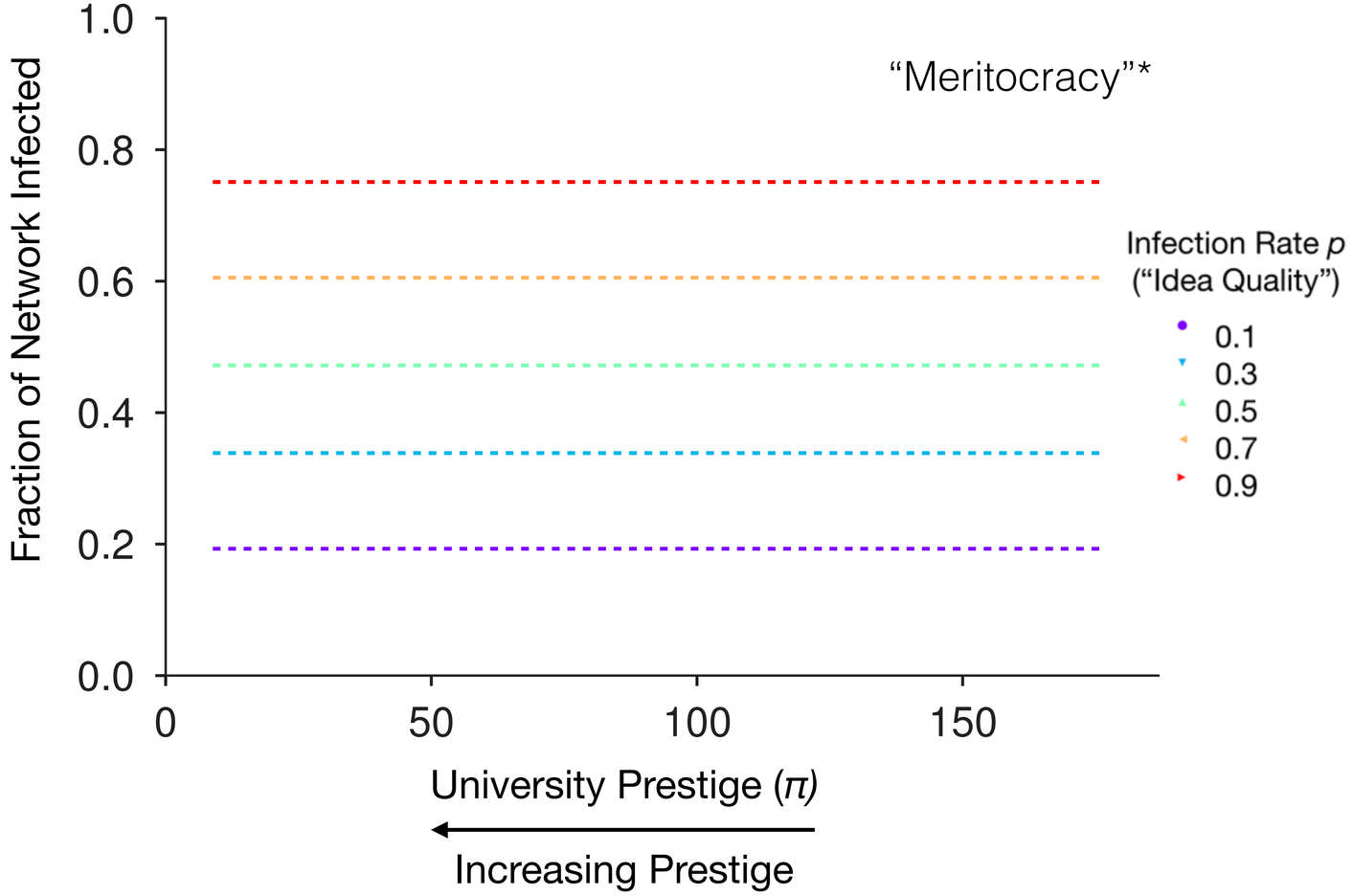
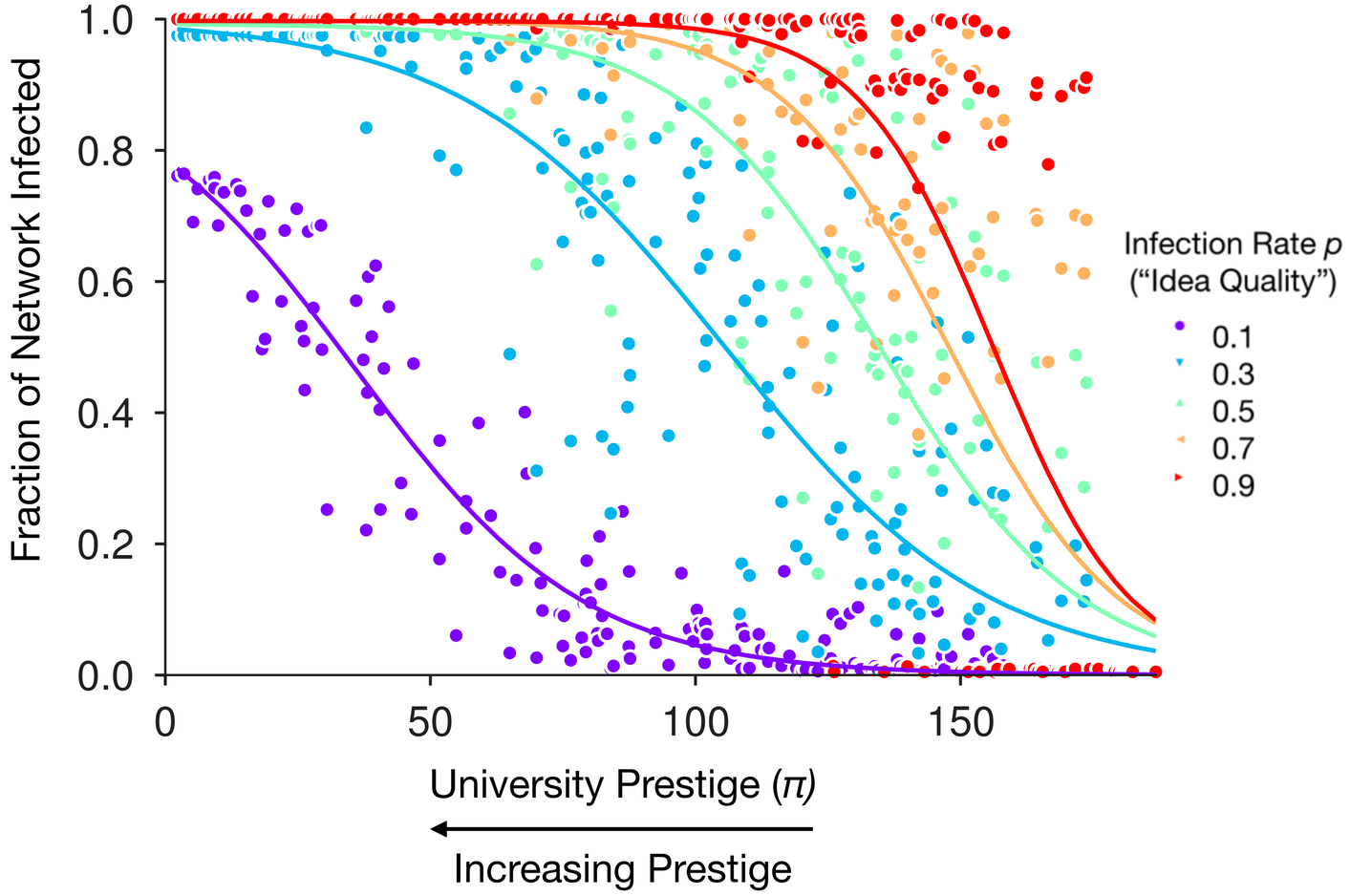


* Assuming independence between quality of idea and origin; https://en.wikipedia.org/wiki/Meritocracy#Etymology

R2: Does the structure of the faculty hiring network affect the spread of ideas?



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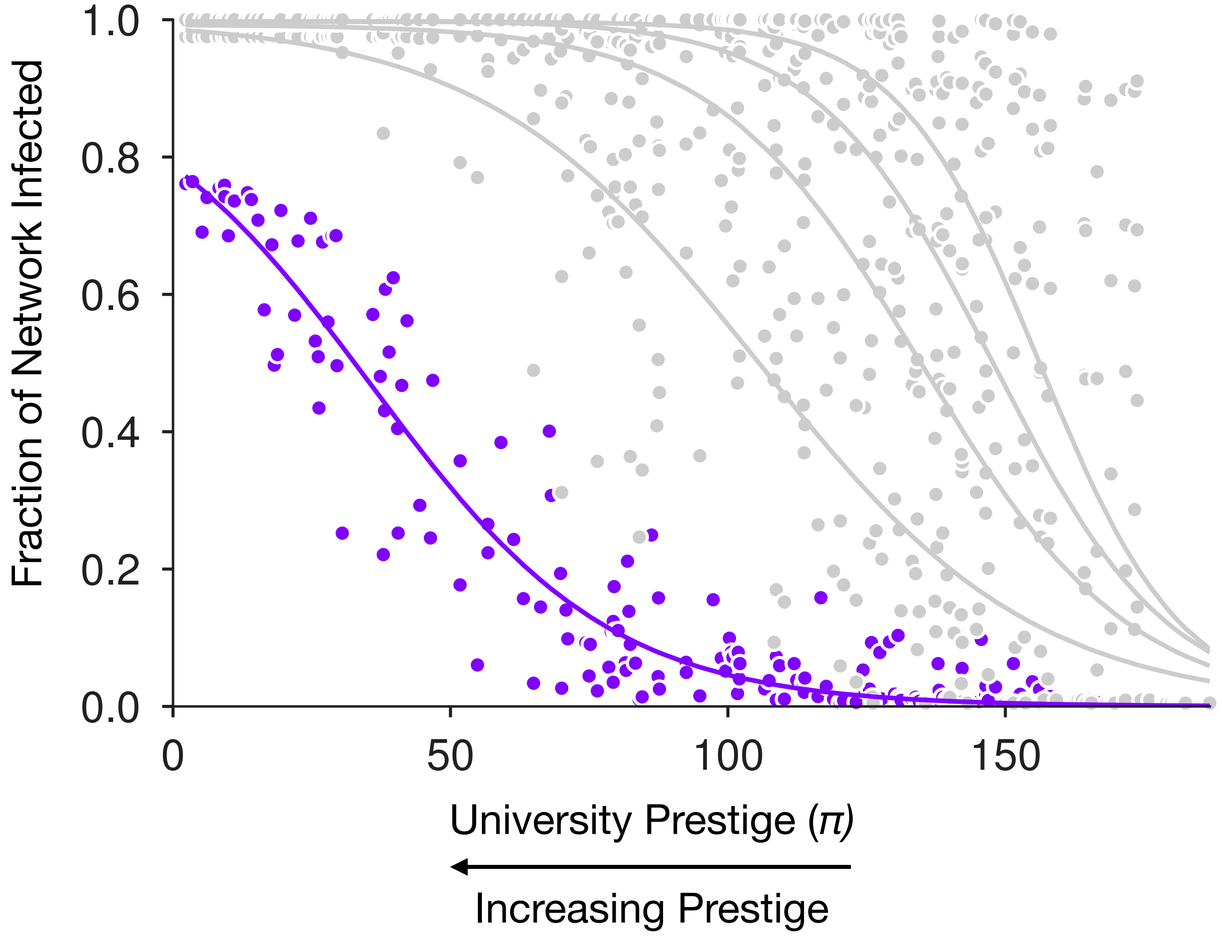
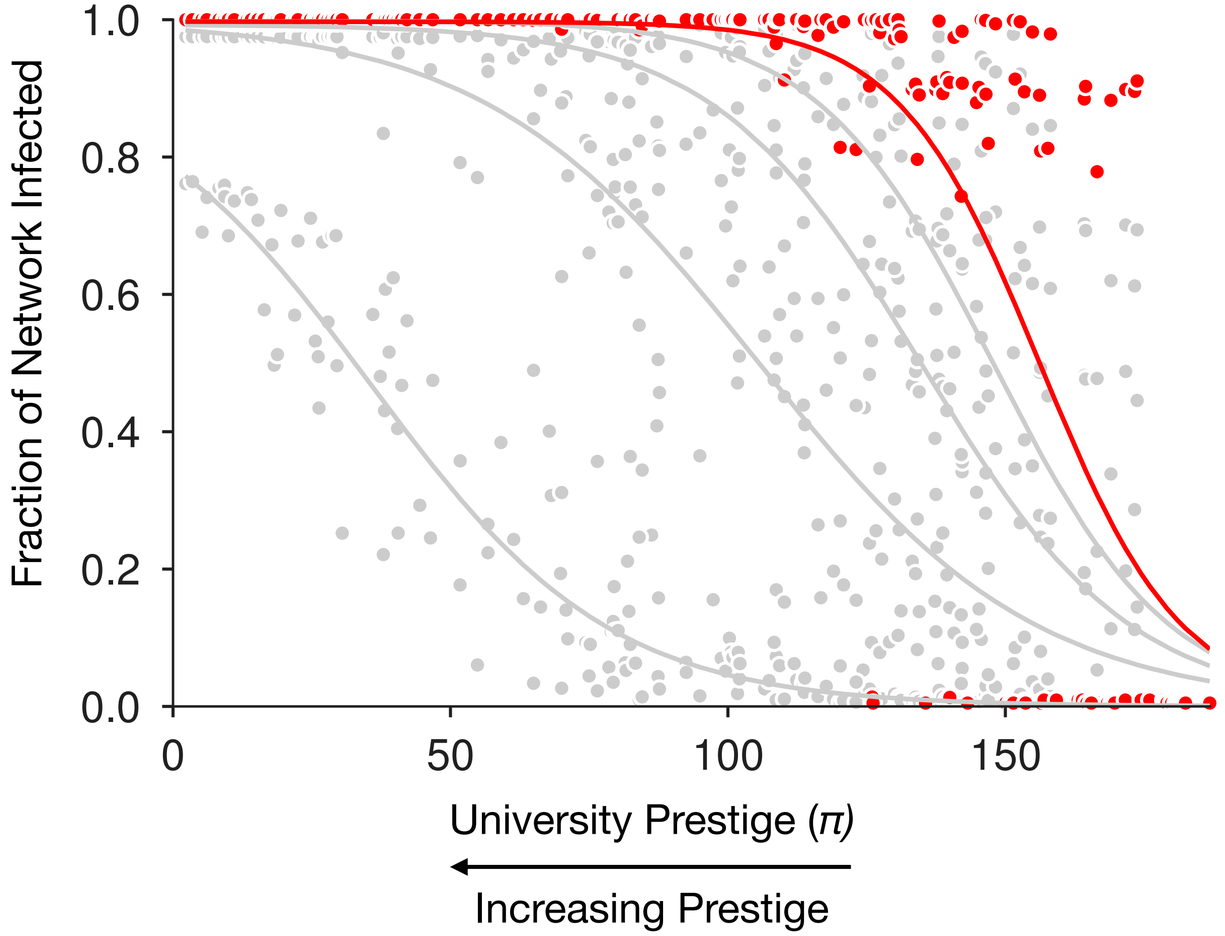


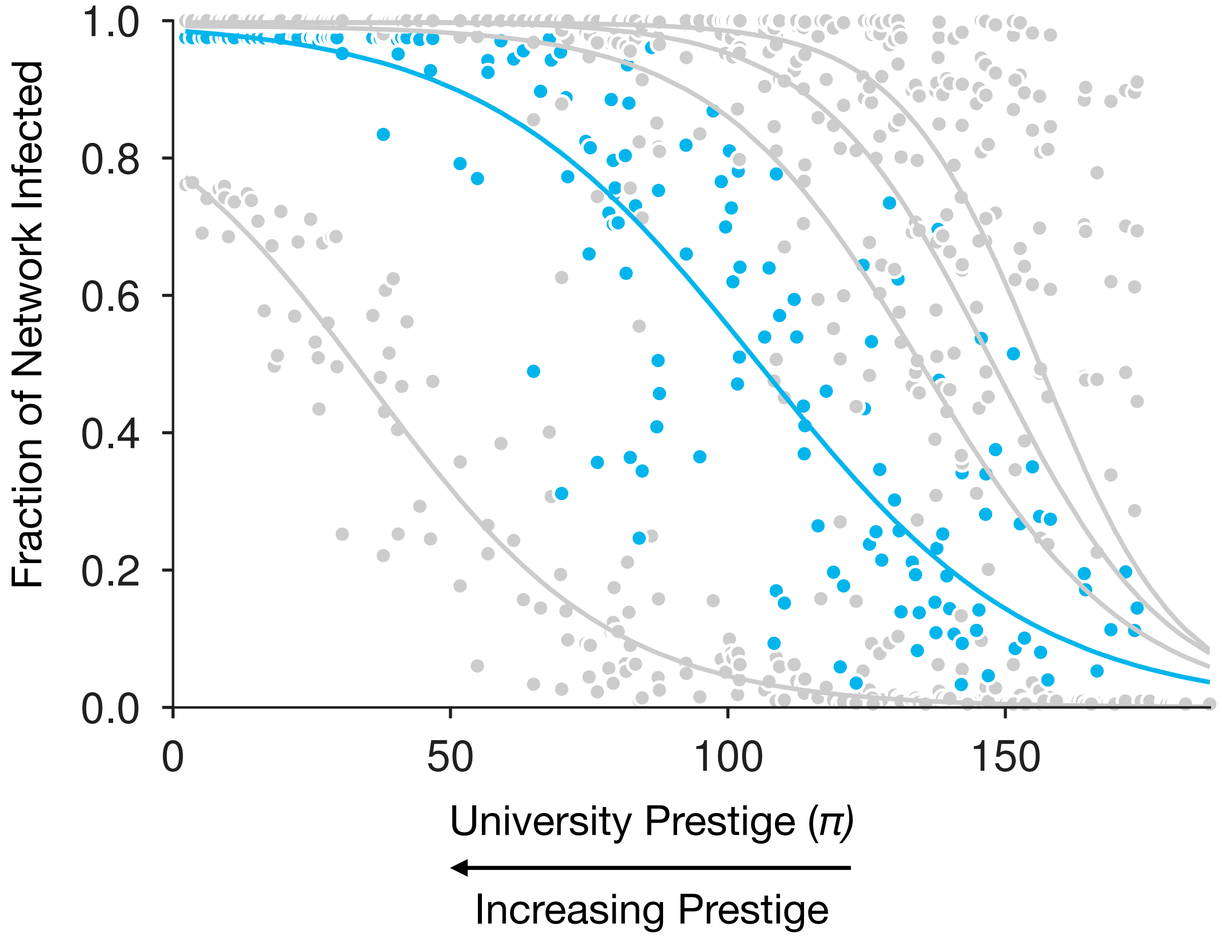
Good ideas spread more easily from high-prestige universities

R2: Does the structure of the faculty hiring network affect the spread of ideas?



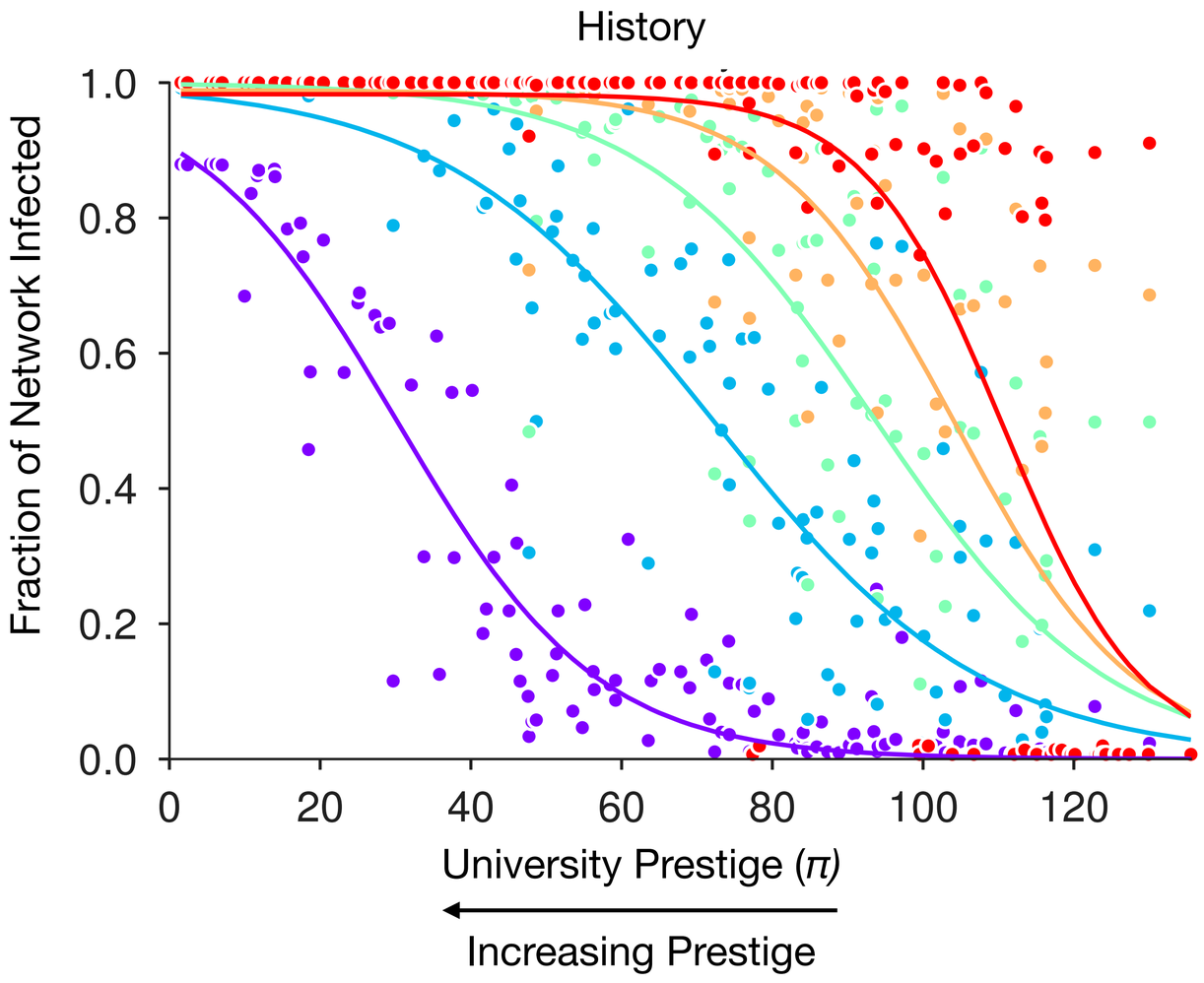
Great ideas can spread regardless of starting place

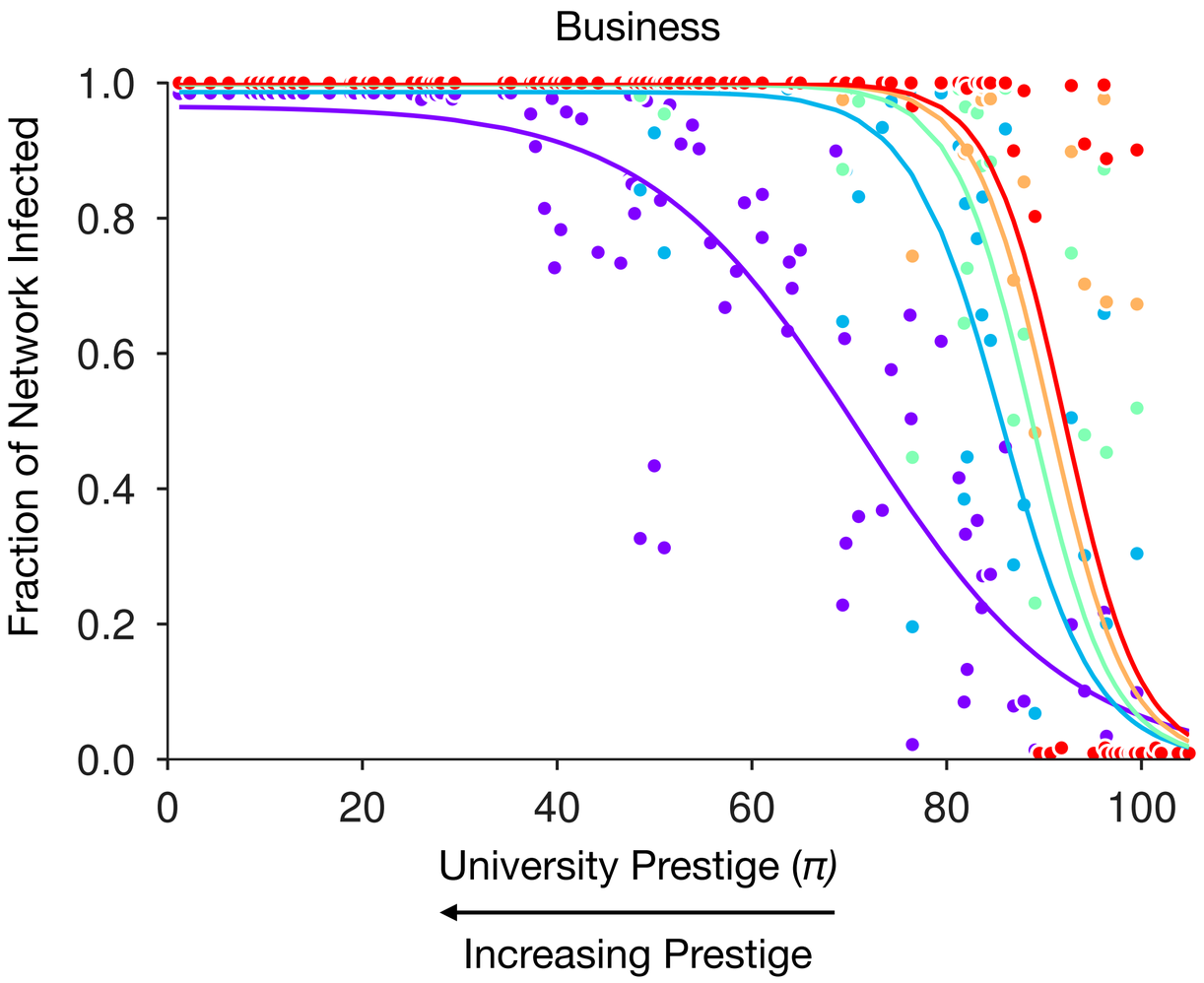
R2: Does the structure of the faculty hiring network affect the spread of ideas?



We may lose medium quality research ideas because the system structurally disallows their spread

Aside: What about other fields?

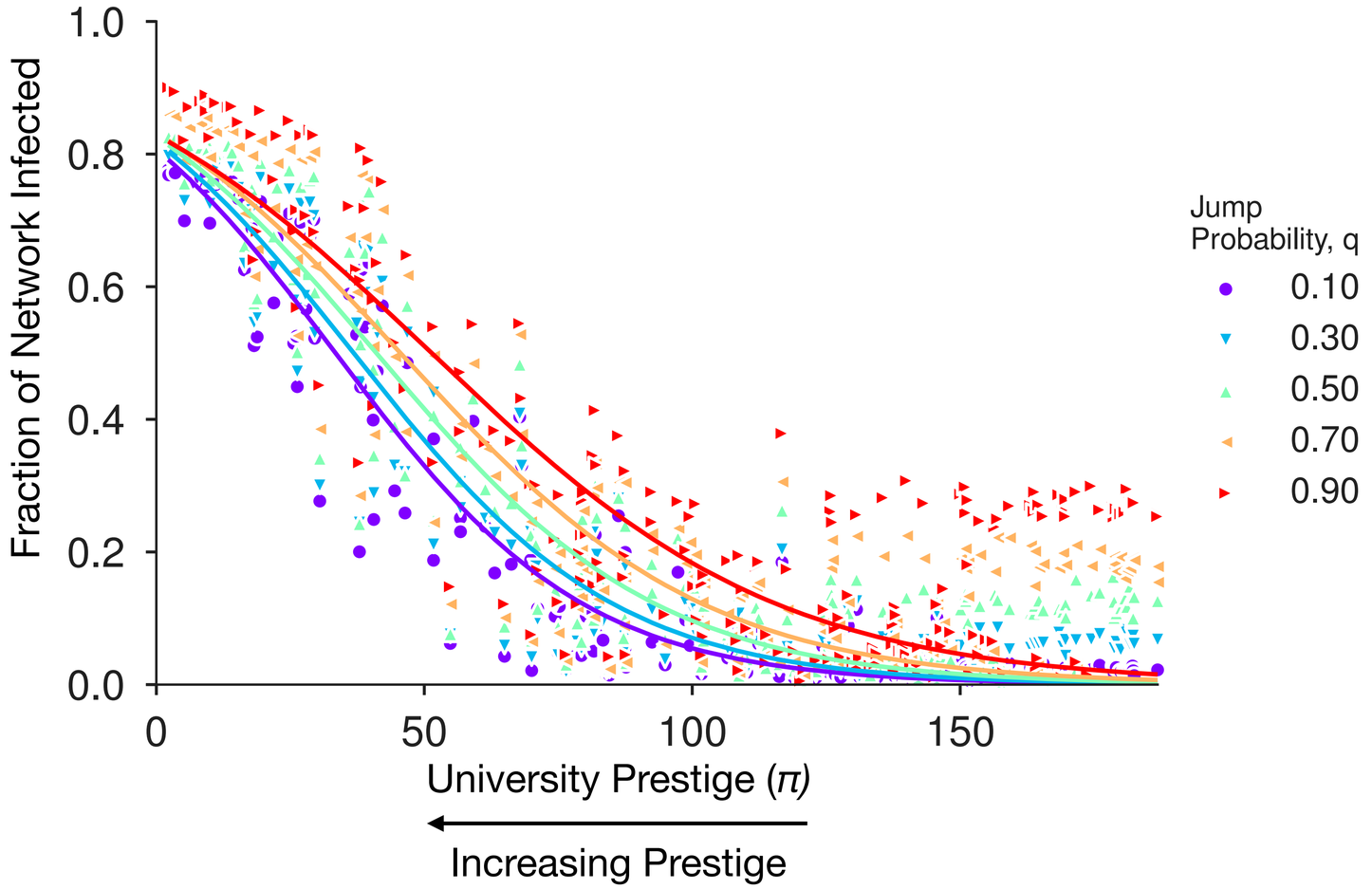




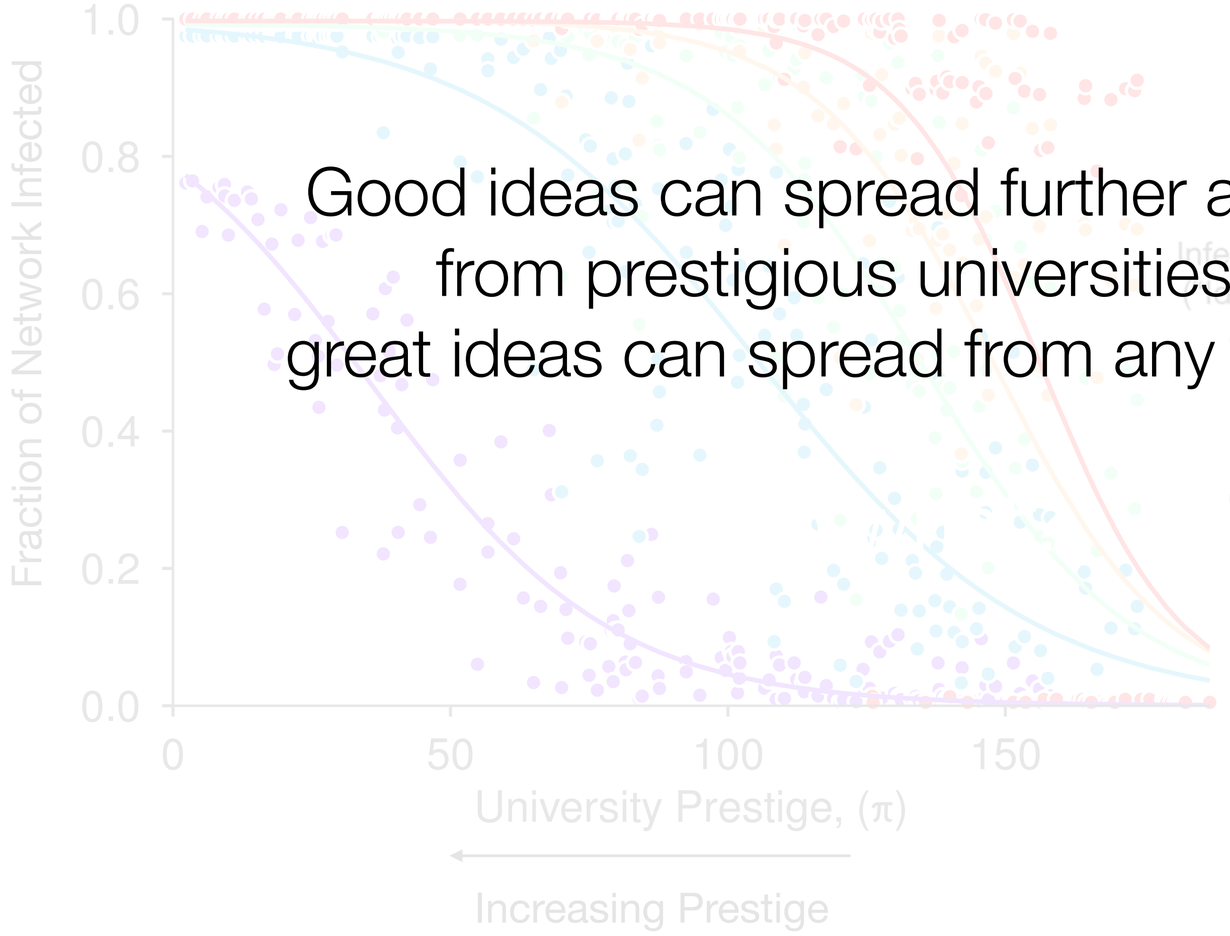
Gini coefficient for history is 0.72, business is 0.62, and computer science is 0.69.

Aside: What about other mechanisms?

Allowing a single jump to a disconnected node.
Transmission probability is held constant at 0.1

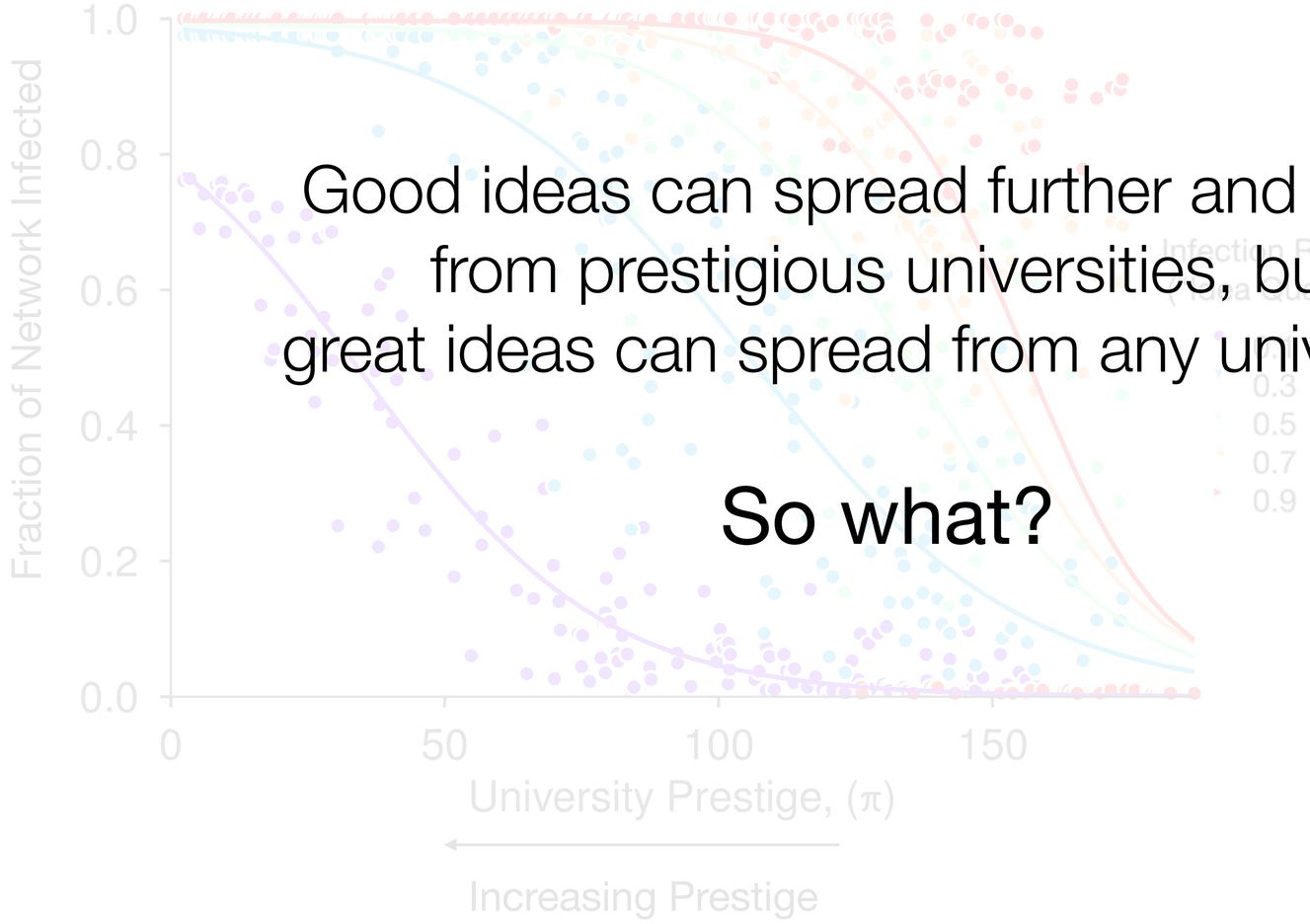


R2: Does the structure of the faculty hiring network affect the spread of ideas?



Good ideas can spread further and faster
from prestigious universities, but
great ideas can spread from any university.

R2: Does the structure of the faculty hiring network affect the spread of ideas?



Good ideas can spread further and faster from prestigious universities, but great ideas can spread from any university.

So what?

Goals for this talk:

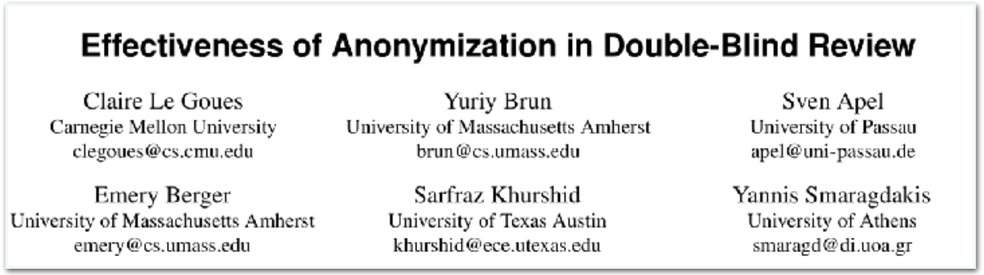
1. Quantifying prestige in academia
2. Identify a structural mechanism for how prestige affects research progress
3. Discuss implications

Conclusions

Ideas spread in academia via faculty hiring. The structure of this network can privilege elite institutions.

Caveats: Model assumes quality is independent of institution and hiring decisions.

To mitigate this, we could try to remove signals of prestige from our evaluations of quality (e.g., double-blind review).



Effectiveness of Anonymization in Double-Blind Review

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https://dl.acm.org/citation.cfm?doid=3229066.3208157

The NIPS experiment

Dec 15, 2014 · Eric Price

http://blog.mrtz.org/2014/12/15/the-nips-experiment.html

Reviewer bias in single- versus double-blind peer review

Andrew Tomkins[a,1], Min Zhang[b], and William D. Heavlin[a]

Proc. Natl. Acad. Sci. U.S.A. (2017)

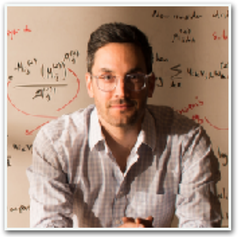
Systems which incentivize a large quantity of incremental ideas will tend promote the visibility of prestigious researchers.

Thought experiments: What if hiring was random? What if the lowest ranked universities chose first? What other non-meritocratic mechanisms might be at play? Could we validate these findings empirically?

Thanks!

Collaborators: Dimitrios Economou, Samuel Way, Aaron Clauset, Daniel Larremore, McKenzie Mae Weller

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NSF

Systematic inequality and hierarchy in faculty hiring networks

Aaron Clauset,[1,2,3]* Samuel Arbesman,[4] Daniel B. Larremore[5,6]

Science Advances 1(1), e1400005 (2015)

Prestige drives epistemic inequality in the diffusion of scientific ideas

Allison C. Morgan[1]*, Dimitrios J. Economou[1], Samuel F. Way[1] and Aaron Clauset[1,2,3]

EPJ Data Science 7:40 (2018)

Gender, Productivity, and Prestige in Computer Science Faculty Hiring Networks

Samuel F. Way,[1,*] Daniel B. Larremore,[2,†] and Aaron Clauset[1,3,2,‡]

Proc. 25th Int'l World Wide Web Conf. (2016)

Automatically assembling a full census of an academic field

Allison C. Morgan[1]*, Samuel F. Way[1], Aaron Clauset[1,2,3]

PLoS ONE 13(8): e0202223 (2018)

The misleading narrative of the canonical faculty productivity trajectory

Samuel F. Way[a,1], Allison C. Morgan[a], Aaron Clauset[a,b,c,2], and Daniel B. Larremore[a,b,c,1,2]

Proc. Natl. Acad. Sci. U.S.A. (2017)

Productivity, prominence, and the effects of academic environment

Samuel F. Way[a,1], Allison C. Morgan[a], Daniel B. Larremore[a,b,2], and Aaron Clauset[a,b,c,1,2]

Proc. Natl. Acad. Sci. U.S.A. (2019)