Modeling the leaky pipeline in hierarchical professions

Sara M. Clifton St. Olaf College March 9, 2021

Women are 46% of the workforce, but their representation falls in more senior positions





Many industries are structured hierarchically

- business
- medicine
- law
- politics
- academia
- education
- journalism
- entertainment



Published: Sept 15, 2018 1:10 p.m. ET

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^m Why?

An Ohio State University study reveals that in order to succeed, women need to be around other women



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EDUCATION

The Stubborn Culture of Harassment in America's Medical Schools

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July 12, 2012 · 4:58 PM ET Heard on All Things Considered

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Ayodhya Ouditt/NPR

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Ayodhya Ouditt/NPF

The Price All Women Pay For Gender Bias

JACOB STERN AND DAVID YAFFE-BELLANY JAN 15, 2019

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Working Women Often Underestimate Motherhood Costs

Why? Quit Science

Why leaving the workforce after having kids is an unexpected, reluctant choice for some



Ayodhya Ouditt/NPF

How Stereotypes Can Drive Women To

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10,425 views | Jan 31, 2018, 09:00am

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Why women are poor at science, by Harvard president



How Stereotypes Can Drive Women To Why? Quit Science

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"Leaky Pipeline" Model



Shaw & Stanton (2012)

"Time to Parity" Model

Holman et al. (2018)

fraction women



Is gender parity inevitable?



Build a minimal model

Fact 1

People self-segregate (called "homophily")



Build a minimal model

<u>Fact 2</u>

Bias by hiring committees exists



Build a minimal model

Both **bias** and **homophily** impact the ascension of people through professional hierarchies









HOMOPHILY { probability that man applies for promotion: 50% probability that woman applies for promotion: 25%





group applying for promotion (25% women)





HOMOPHILY { probability that man applies for promotion: 50% probability that woman applies for promotion: 25%







BIAS { probability that man is promoted: 67% probability that woman is promoted: 50%

group applying for promotion (25% women)



HOMOPHILY { probability that man applies for promotion: 50% probability that woman applies for promotion: 25%







group granted a promotion (20% women)



BIAS { probability that man is promoted: 67% probability that woman is promoted: 50%

group applying for promotion (25% women)





HOMOPHILY { probability that man applies for promotion: 50% probability that woman applies for promotion: 25%













Model behavior: effect of bias















What does the model say about the real world?

Data

- Academic Psychology
- Academic Math & Statistics
- Academic Computer Science
- Academic Engineering
- Academic Chemistry
- Academic Physics
- Academic Biology
- Academic Physical Sciences
- Academic Clinical Medicine
- Academic Scientific Medicine
- Academic English

- Academic Languages
- Engineering Practice
- Journalism Practice
- Medical Practice
- Nursing Practice
- Law Practice
- K-12 Education
- Politics
- Business
- Film
- Orchestras

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- Law Practice
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- Politics
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- Orchestras

Academic Academic Psychology **Clinical Medicine** (a) (b) medical assistant associate full chair fraction women alann bachelor graduate assistant 00000000 associate – full N ſ 2050 2060 1980 1970 time (years) time (years)









Intervention: target hiring committees







Intervention: target potential applicants













Racial bias and homophily





Laurie Balstad St. Olaf College

general population

Racial bias and homophily



Hierarchy: Academic medicine in US universities

Thanks



Undergraduate researchers Grace Sun, Alan Zhou, Patrick McMahon (UIUC), and Laurie Balstad (St. Olaf)



Mathways grant DMS 1449269

Illinois Geometry Lab

Q<u>SIDE</u>

Institute for the Quantitative Study of Inclusion, Diversity, and Equity



Eric Autry (Duke)



Kaitlin Hill (Wake Forest)



Avi Karamchandani (U. Arizona)

Supplemental

Modeling bias and homophily

Definition: the fraction of those promotedIwho are women if the applicant pool isaevenly split by gendert

Bias

Homophily

Definition: the sensitivity of potential applicants to demographic deviations from their current position







$$\frac{1}{R_L} \frac{dx_L}{dt} = \overbrace{f(x_L, x_{L-1}; b)}^{\text{promoted from}} - \overbrace{x_L}^{\text{retire out}} f(u, v; b) = \frac{b v P(u)}{b v P(u) + (1 - b)(1 - v)P(1 - u)}$$

$$\frac{1}{R_j} \frac{dx_j}{dt} = (1 + r_j) f(x_j, x_{j-1}; b) - x_j - r_j f(x_{j+1}, x_j; b)$$

$$P(u, v) = \frac{1}{1 + e^{-\lambda(u - v)}}$$

$$\frac{1}{R_1} \frac{dx_1}{dt} = \underbrace{(1 + r_1) f(x_1, \frac{1}{2}; b)}_{\text{hired from}} - \underbrace{x_1}_{\text{fedd}} - \underbrace{r_1 f(x_2, x_1; b)}_{\text{promoted to}}$$

$$\frac{Variable \text{ Meaning}}{R_j \text{ retirement/leave rate at the jth level}}$$

$$R_j \text{ retirement/leave rate at the jth level} r_j \text{ ratio of the total retiring people in the jth level} r_j \text{ ratio of seeking promotion}$$

$$f(\cdot) \text{ fraction of people promoted to next level who are women} b b is towards or against women (b = 1/2 is no bias)}$$

Model behavior: both bias and homophily















