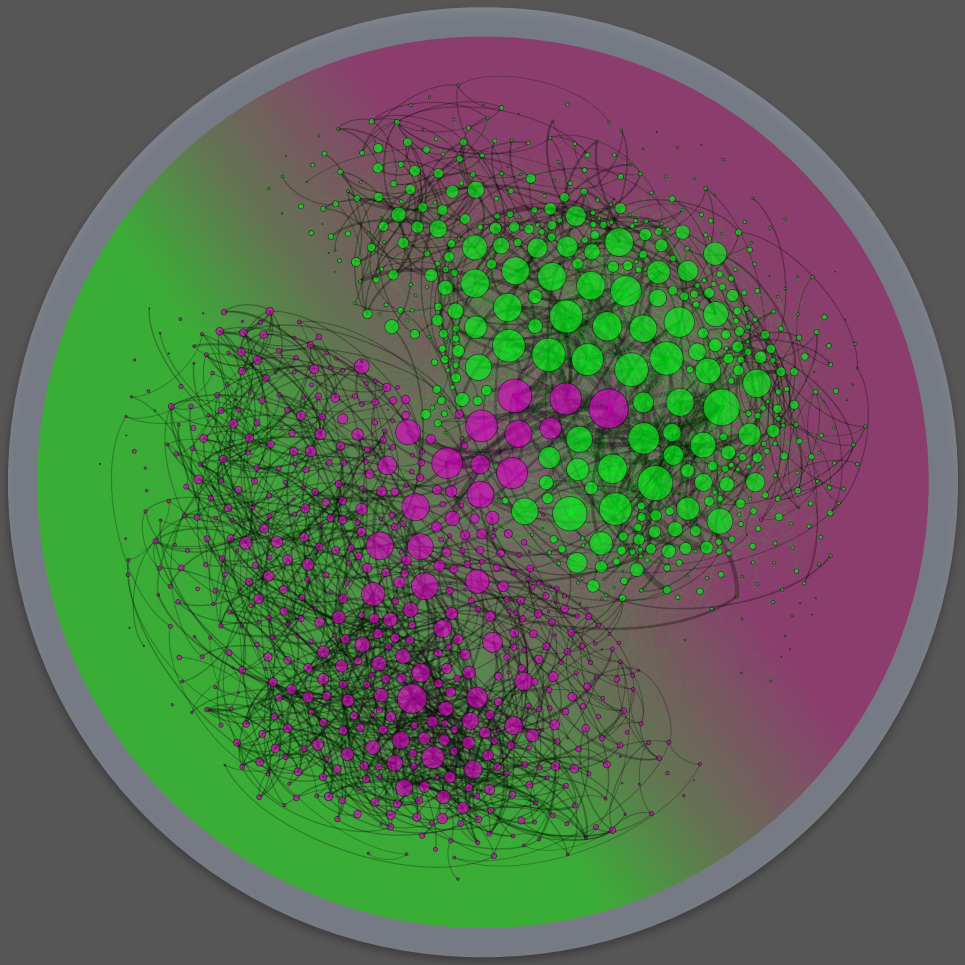
— When scientists cross the line —

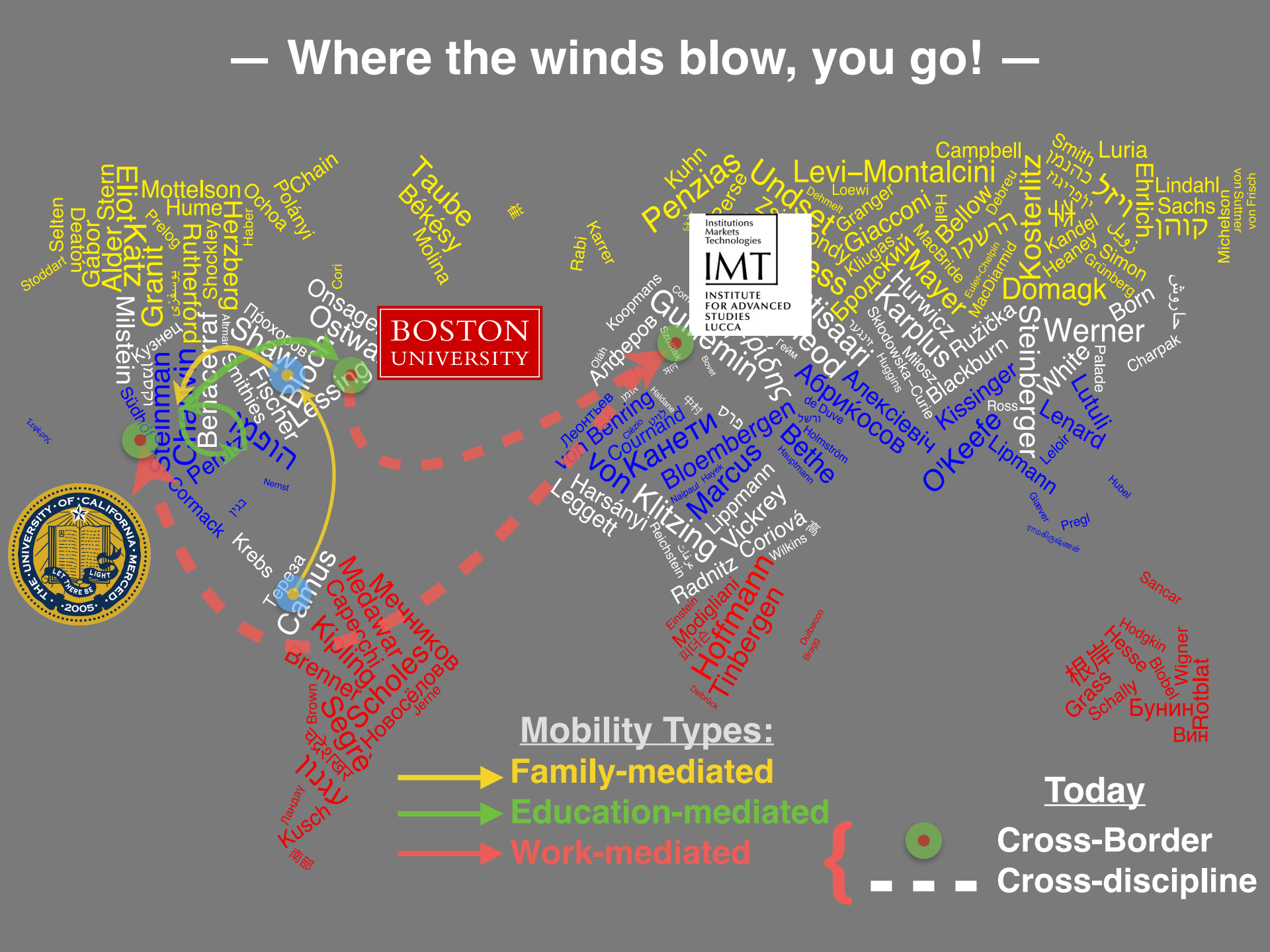


UNIVERSITY OF CALIFORNIA
MERCED

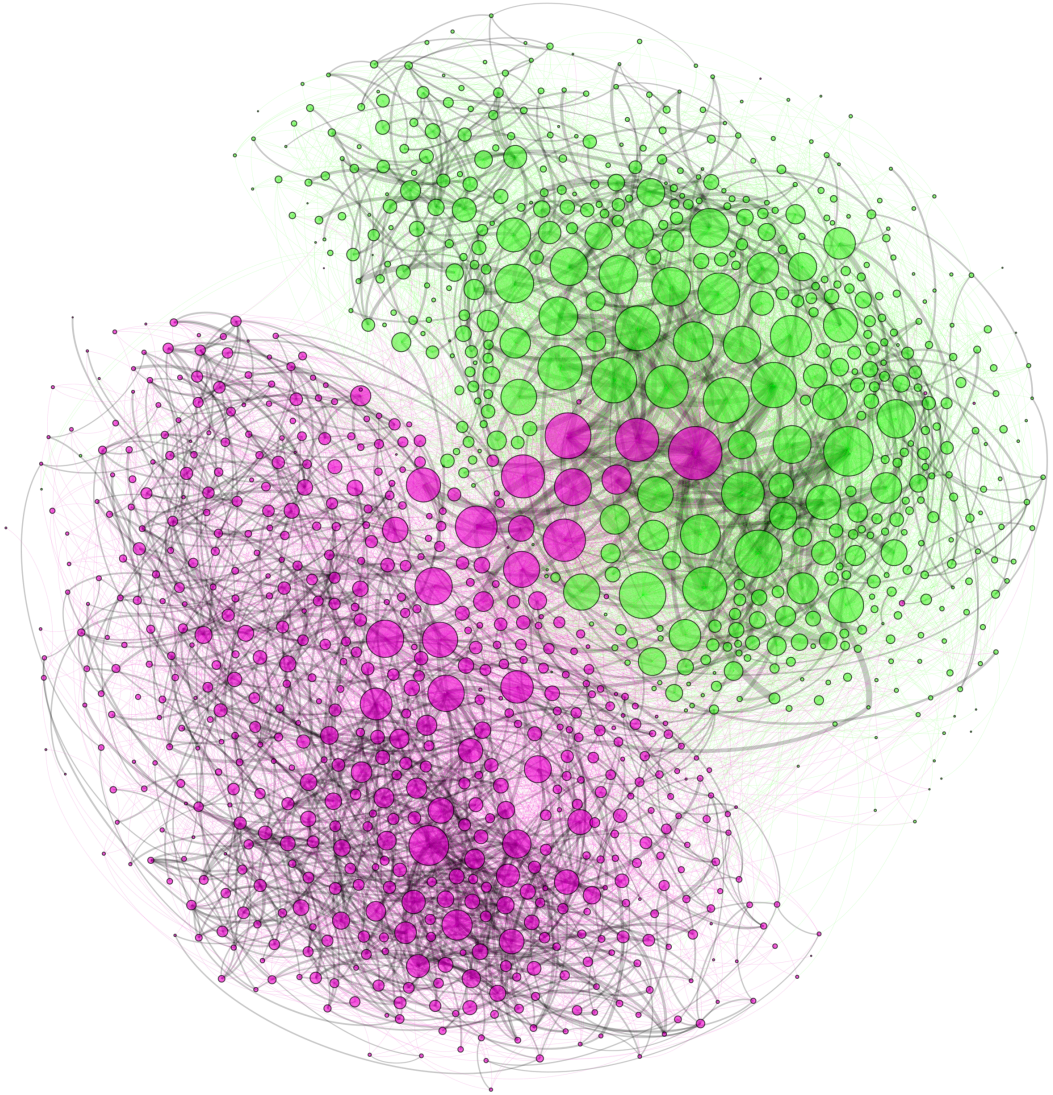
Alexander M. Petersen

Management of Complex Systems Department

Ernest and Julio Gallo Management Program — School of Engineering


— Where the winds blow, you go! —
BOSTON UNIVERSITY
Institutions Markets Technologies
IMT
INSTITUTE FOR ADVANCED STUDIES LUCCA
Mobility Types:
Family-mediated
Education-mediated
Work-mediated
Today
Cross-Border
Cross-discipline

Part 1 — Cross-disciplinary Collaboration & Mobility



Cross-disciplinary Evolution of the Genomics Revolution — Science Advances (2018)

Data & Methods: ~80 US Biology and Computing Departments faculty directories > Master List of Scholars

— we then collected data from their 4,190 Google Scholar profiles, comprising 413,565 publications

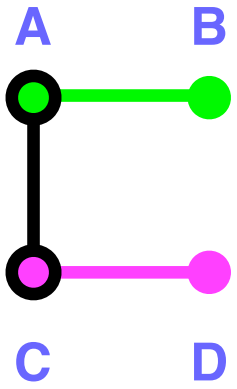
Author i	Coauthors	Department $\mathcal{F}_i$	Orientation $\mathcal{O}(\mathcal{F}_i)$
A	B,C	BIO	XD
B	A	BIO	BIO
C	A,D	CS	XD
D	C	CS	CS

Direct link: publication between scholar i and j

Mono-Disc. scholar : $\mathcal{O}_i(\mathcal{F}) = \mathrm{BIO}$

Mono-Disc. scholar : $\mathcal{O}_i(\mathcal{F}) = \mathrm{CS}$

Cross-Disc. scholar : $\mathcal{O}_i(\mathcal{F}) = \mathcal{X}$



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Author i	Coauthors	Department $\mathcal{F}_i$	Orientation $\mathcal{O}(\mathcal{F}_i)$
A	B,C	*BIO*	*XD*
B	A	*BIO*	*BIO*
C	A,D	*CS*	*XD*
D	C	*CS*	*CS*

Direct link: publication between scholar i and j

Mono-Disc. scholar : $\mathcal{O}_i(\mathcal{F}) = \mathrm{BIO}$

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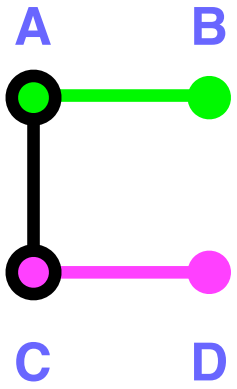


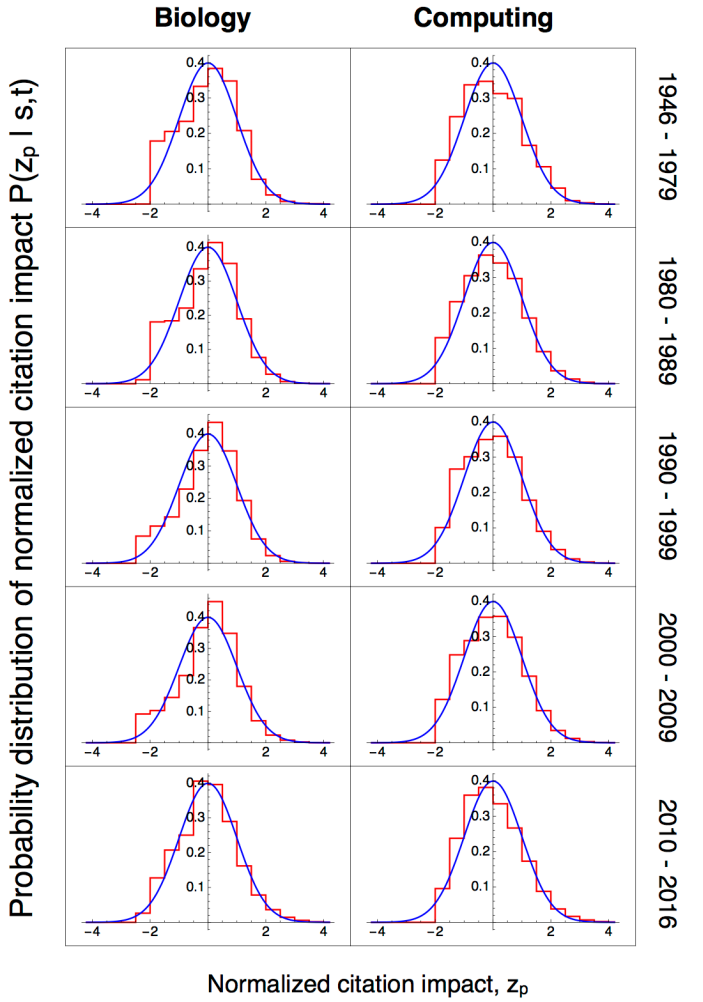
Statistical Method: to overcome temporal bias underlying citation measures

$c_{p,i,t}$ = Google citation total for article p published in year t by Scholar i belonging to faculty $\mathcal{F}$

Normalized or "Detrended" citation impact: ***z-score*** $\mapsto$ $z_{p,i} = \dfrac{\ln(1 + c_{p,i,t}) - \mu_{\mathcal{F},t}}{\sigma_{\mathcal{F},t}}$

This method simply removes the time-dependent location and scale of the underlying log-normal citation distribution

$$\mu_{\mathcal{F},t} \equiv \langle \ln(1 + c_{p,t}) \rangle \qquad \sigma_{\mathcal{F},t} \equiv \sigma[\ln(1 + c_{p,t})]$$



The resulting **normalized citation measure** is well-fit by the Normal N(0,1) distribution, and thus **stationary across time**

Longitudinal Case Study of the **Genomics Revolution** (HGP, 1990-2003)

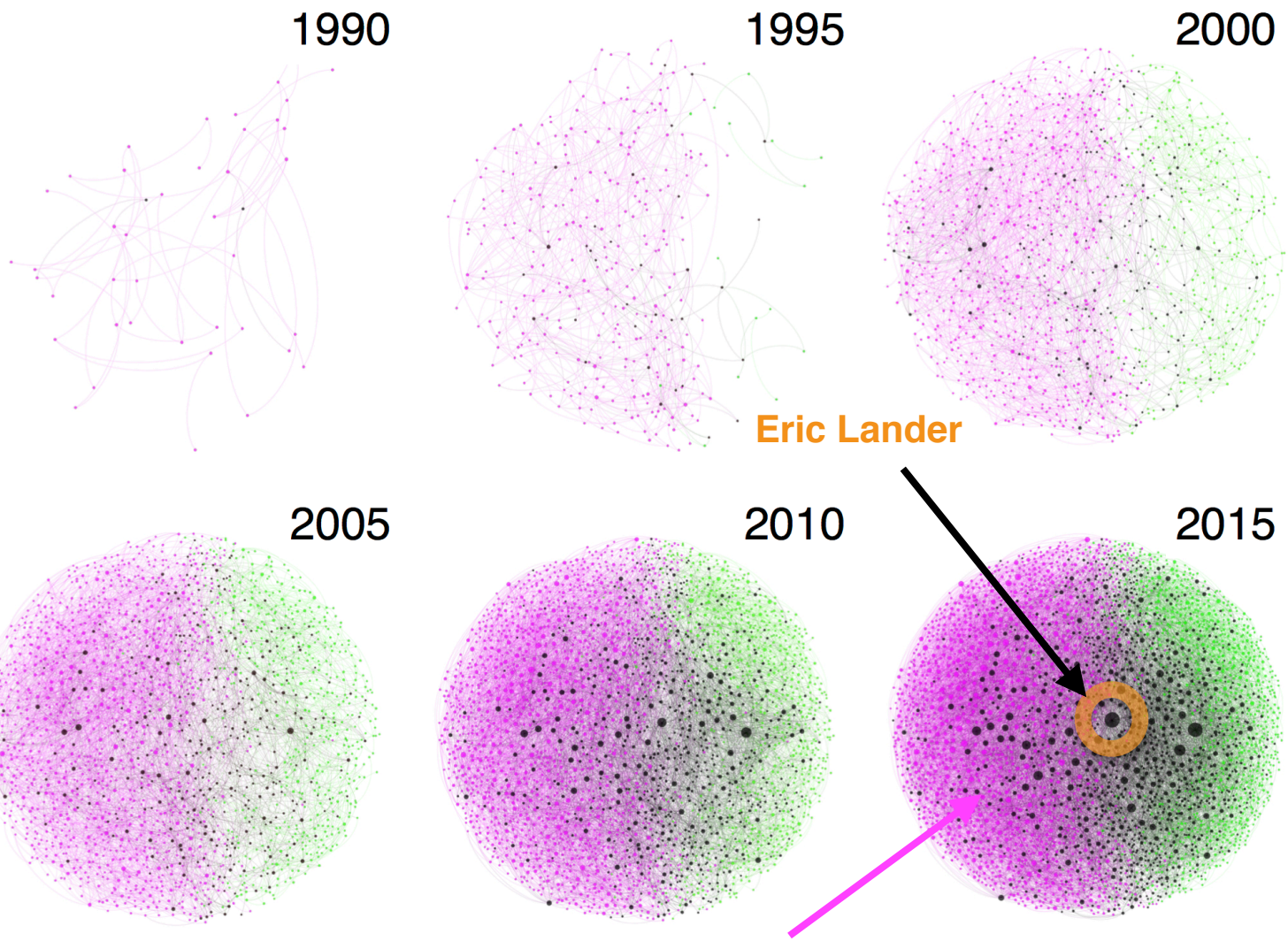
Mono-D collab.

Biology Dept

Cross-Disciplinary (**XD**) collaboration

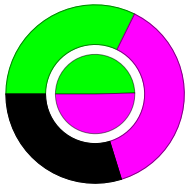
Mono-D collab.

CS/EECS Dept



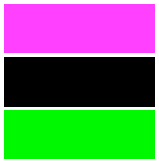
Work in collaboration with Professor Ioannis Pavlidis, Dept. of Computer Science — University of Houston

Model 0



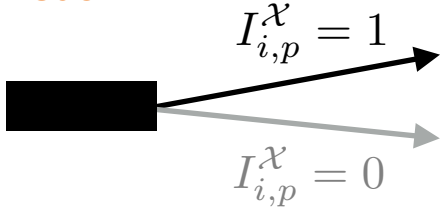
Cross-sectional
All Scholars

Model 1



Panel
All Scholars

Model 2



Panel
XD Scholars only

Model 3

● **XD**

● **Mono-D (1D)**

Panel
Matched publications
(XD Scholars only)

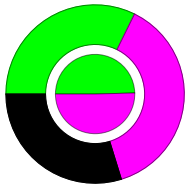
Matching procedure:
same author
~ same year
~ same # coauthors

Panel model specification:
(w/ Author Fixed Effects)
Unit of Analysis = **Publication**

Normalized Citation impact | **# coauthors** | **Career year** | **XD indicator** | **Year dummy**

$$z_{i,p} = \beta_i + \beta_a \ln a_{i,p} + \beta_\tau \tau_{i,p} + \beta_I I^{\mathcal{X}}_{i,p} + \mathrm{D}_t + \epsilon_{i,p}$$

Model 0



Cross-sectional
All Scholars

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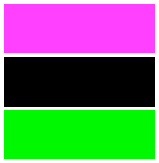
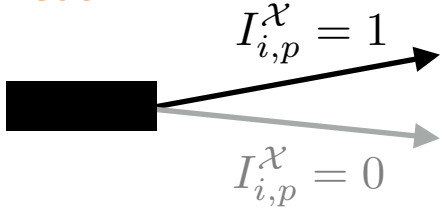


Panel
All Scholars

Model 2



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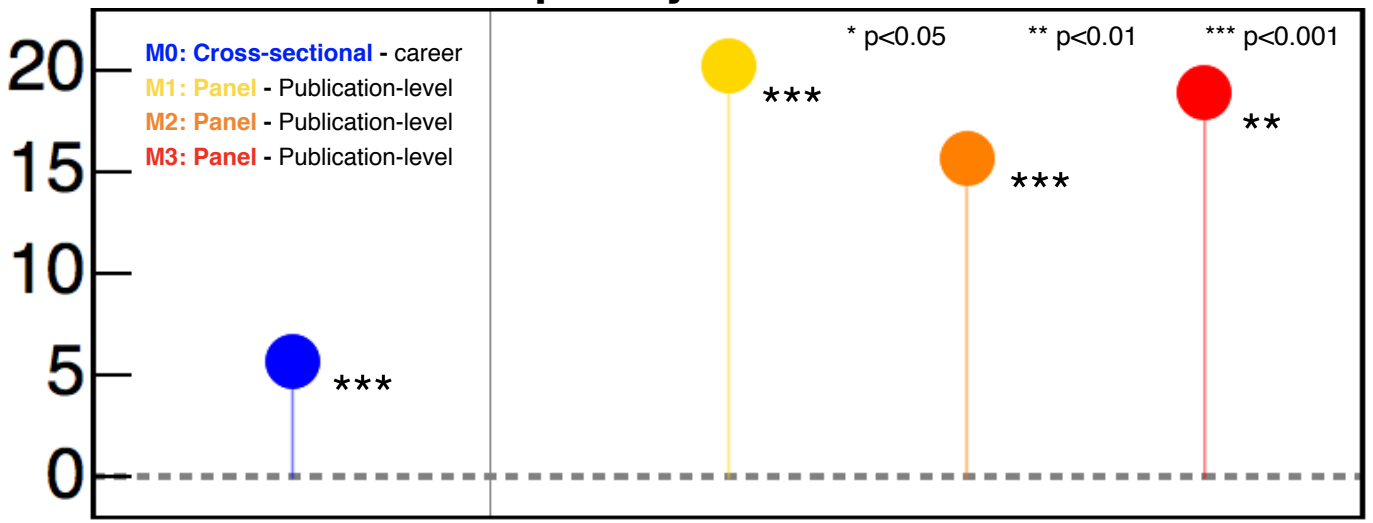
Cross-disciplinary Citation Premium

Percent difference (%) in citations for XD relative to baseline counterfactual = **1D**



Coefficient estimates relation between:

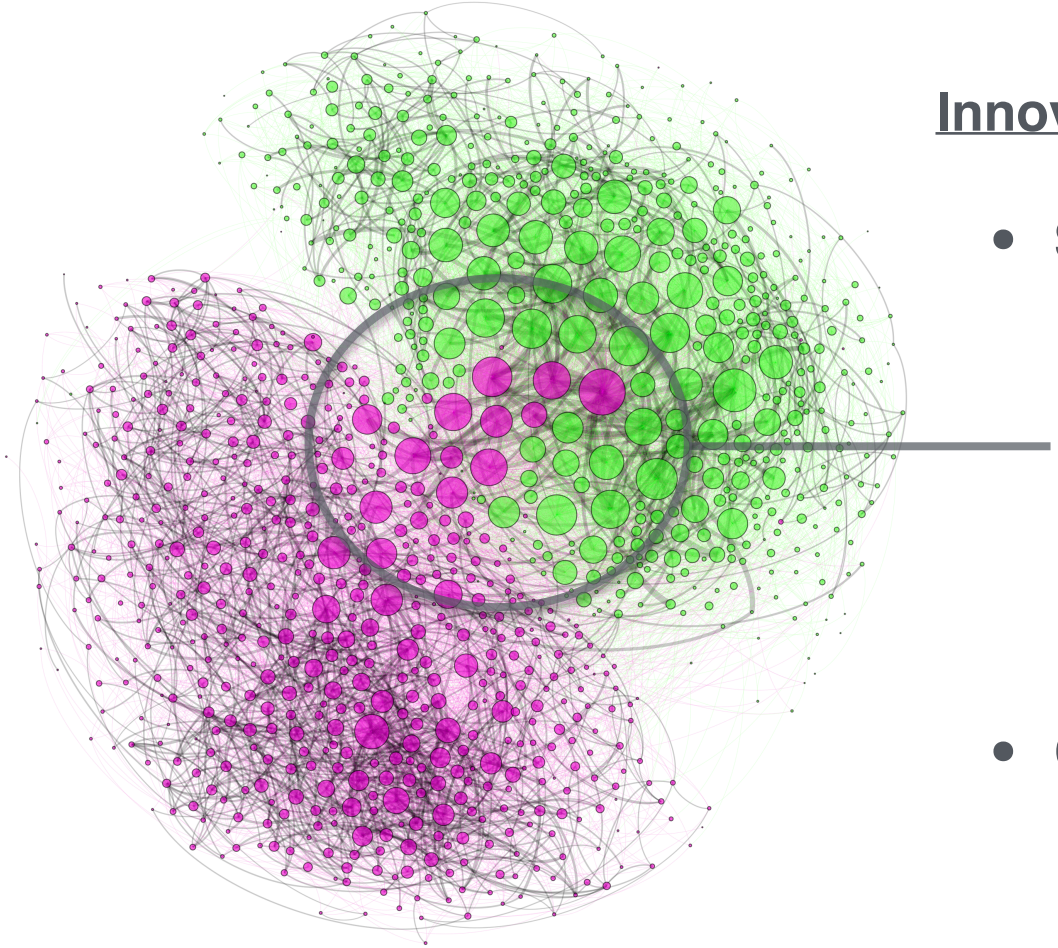
$\beta_{\mathcal{X}}$ = Career citations and Fraction of coauthors that are XD

β_I = Article citations and XD coauthors [coauthors from both BIO and CS, $I^{\mathcal{X}}_{i,p} = 1$]

Scholars with 10% XD-Collaborators are cited ~ 6% more than 1D Scholars from the same discipline
Articles featuring cross-disciplinary combination of authors are cited ~20% more than 1D articles by same author

The HGP — a cross-disciplinary bridge facilitating a highly functional marriage

Biology Faculty

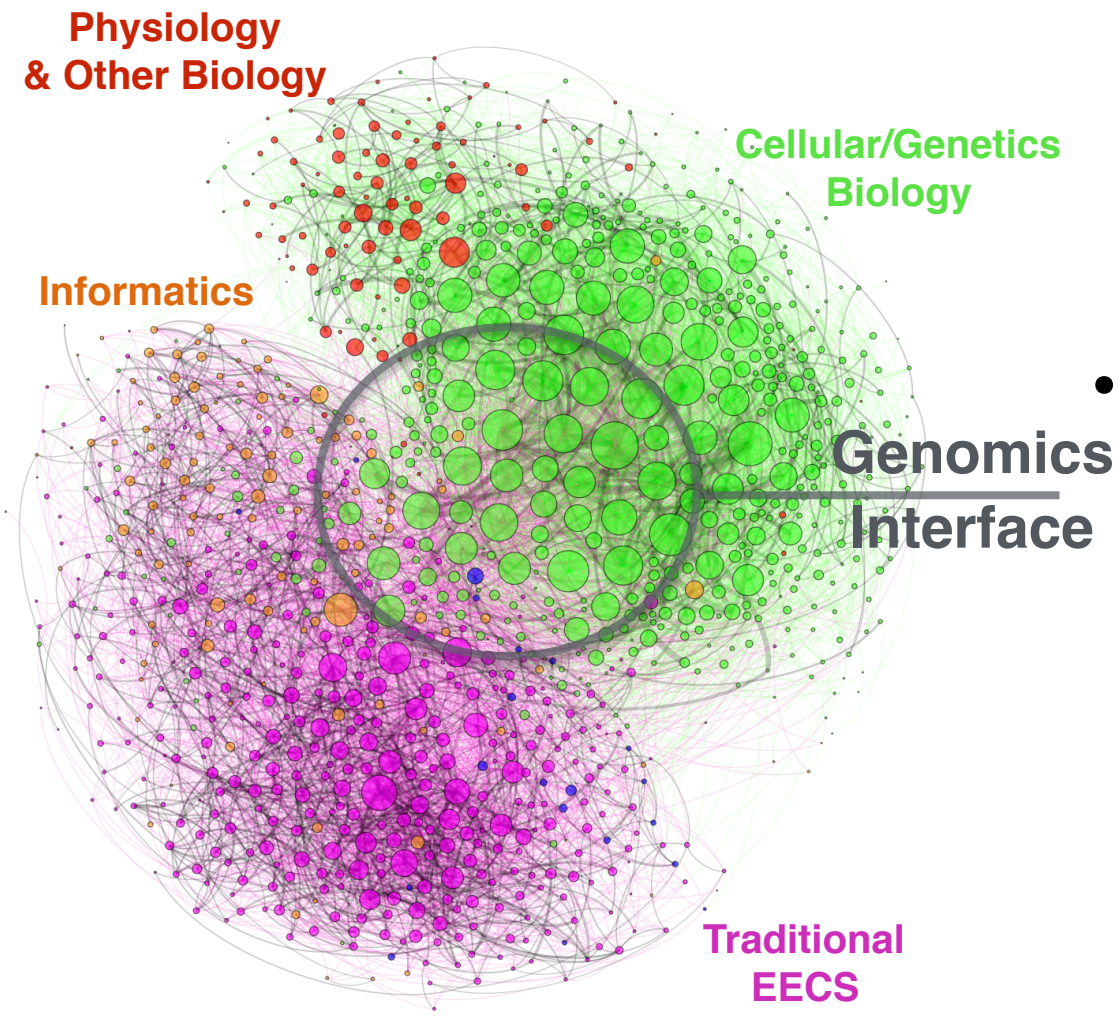


Computer Science Faculty

Innovation @ the genomics interface

- **Success factors:**
  - Methodological diversity leveraging common language
  - Cultural assimilation: XD collaboration facilitates XD mobility of CS into elite BIO
- **Outcomes:**
  - Transformative research
  - Flagship program model
  - Consortium model — *teams of teams*

Disciplinary Propensity revealed by Scholar-Scholar interactions



Implications for Funding Policy/Design

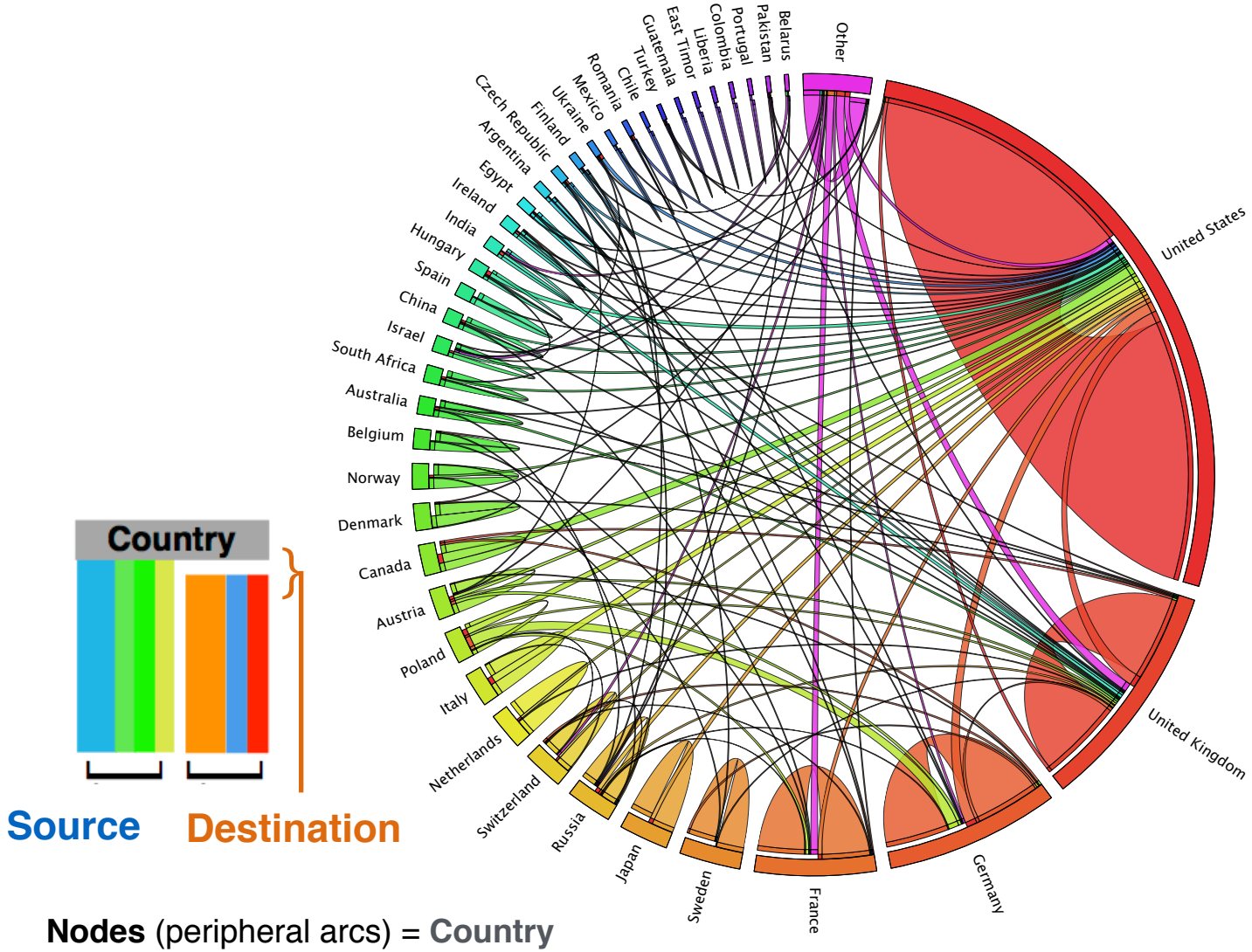
- **Flagship Programs:** funding around Grand Challenges may reduce the barriers associated with disciplinary borders, thereby **incentivizing cross-disciplinary collaboration & mobility**

- ***"Consortium Science"*:** ***teams of teams*** coalesce with common objectives, including sharing benefits equitably within and beyond institutional boundaries **— an organizational model championed by the HGP and further developed by numerous follow-up *"Omics"* consortiums**

Cross-disciplinary Evolution of the Genomics Revolution — Science Advances (2018)

Part 2 — Cross-Border Mobility

Network of Nobel Prize Winners

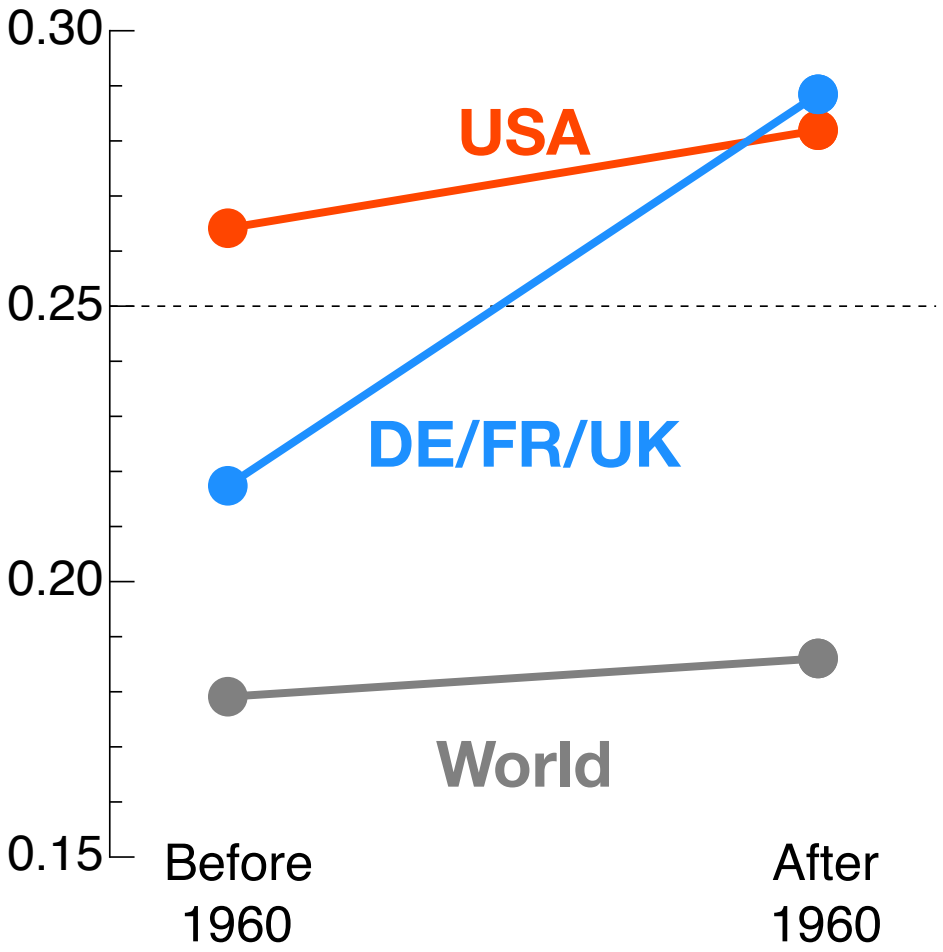


Nodes (peripheral arcs) = **Country**
Directed links: connect **birth country (source)** and **Nobel-achievement country (destination)**

Multiscale Impact of Researcher Mobility — Journal of the Royal Society Interface (2018)

1 in 4 (STEM) Nobel Prize winners are Foreign-born!

Fraction of **Nobel Prize winners** that are **Foreign-born**



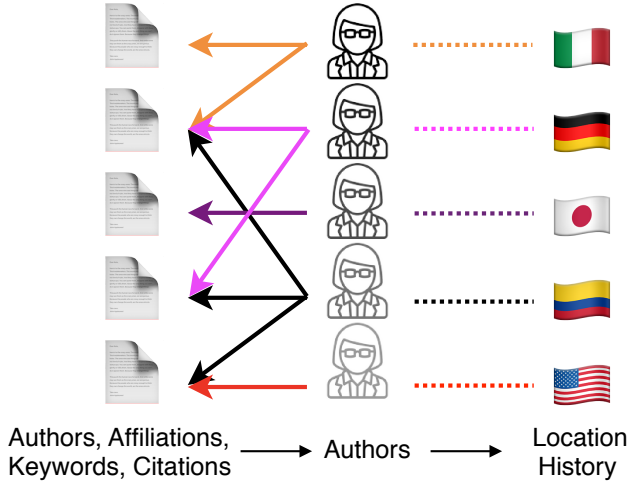
highlights increasingly competitive **international market** for **elite scientists**

— Fishing in Big Data —

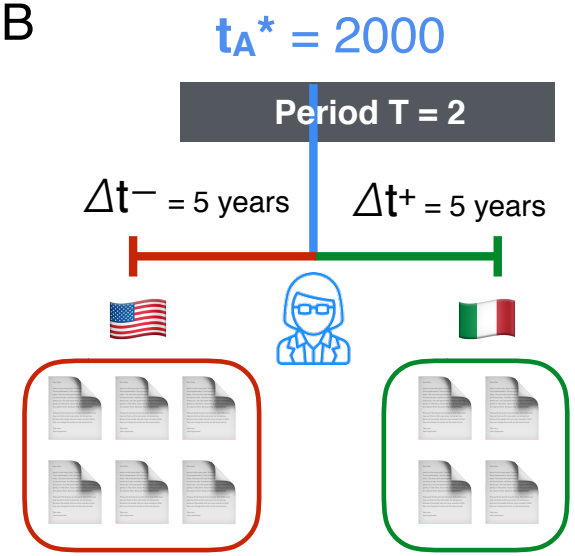
…for counterfactual outcomes that facilitate causal identification

Data & Methods: ~26,000 researcher profiles (1980-2009) extracted from ~350,000 **Physics research articles** published by the *American Physical Society* (1900-2009) — e.g. *Physical Review Letters*, *Physical Review E*, etc.

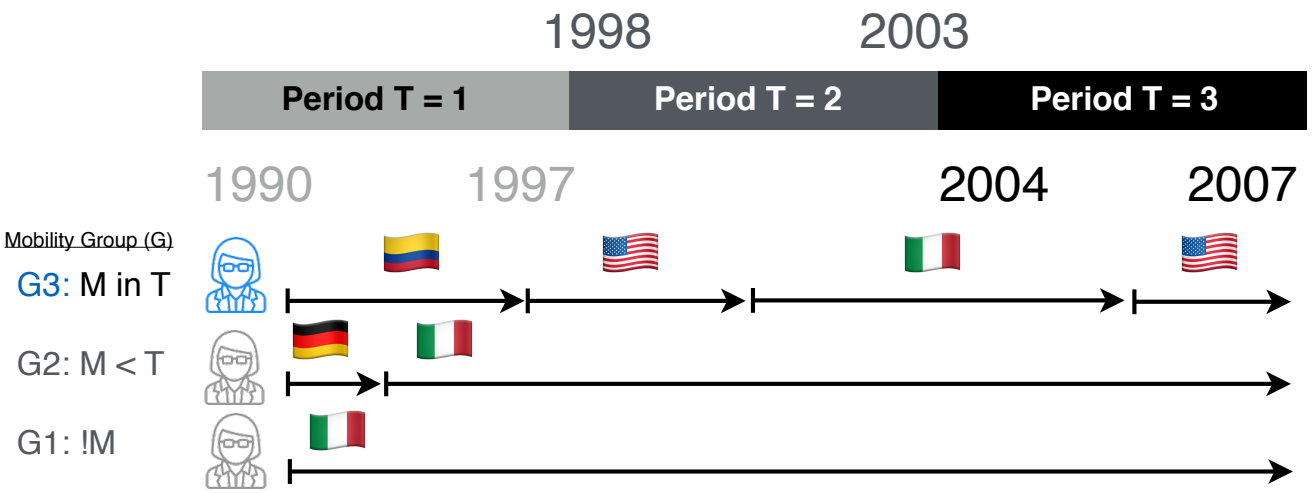
A



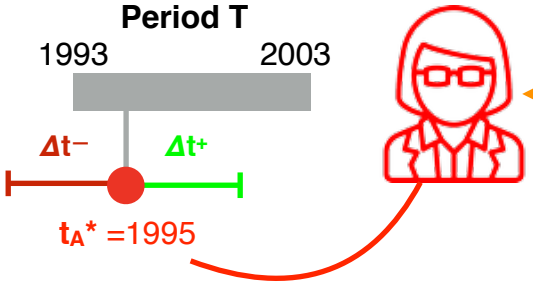
B



C



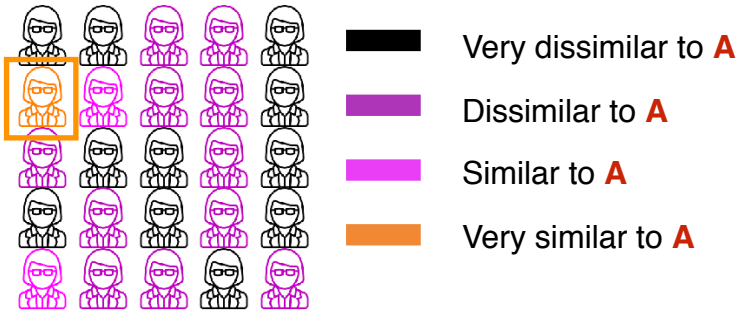
Counterfactual matching method — compare each mobile researcher with the most similar non-mobile researcher and compute difference in **outcome variable Y** ↦ estimation of **"treatment effect on treated" (TET)**



Mobile Researcher A

"Treated" = Mobility event in year **t*** in period **T**

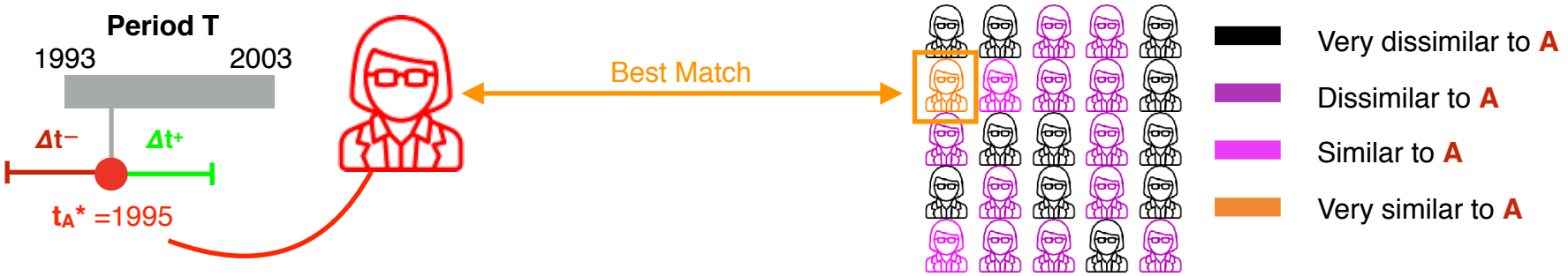
Best Match — based only on data in Δt−



Not-Mobile Researcher Pool

"Control" = No mobility (!M) in period T

Counterfactual matching method — compare each mobile researcher with the most similar non-mobile researcher and compute difference in **outcome variable Y** ↦ estimation of **"treatment effect on treated" (TET)**



Mobile Researcher A
"Treated" = Mobility event in year **t*** in period **T**

Not-Mobile Researcher Pool
"Control" = No mobility (!M) in period T

Mobility effect (TET)
$\Delta Y_A = Y^+_A(M) - Y^+_{bestmatch}(!M)$

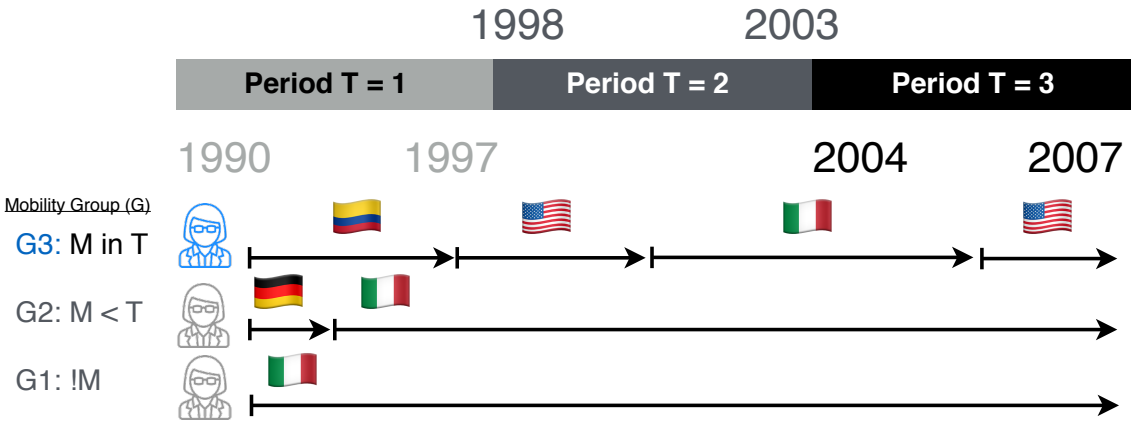
● **G2 = Treatment Group =** Moved < T
G1 = Control Group = Never-moved

● **G3 = Treatment** = Moved in T
G2 = Control = Moved < T

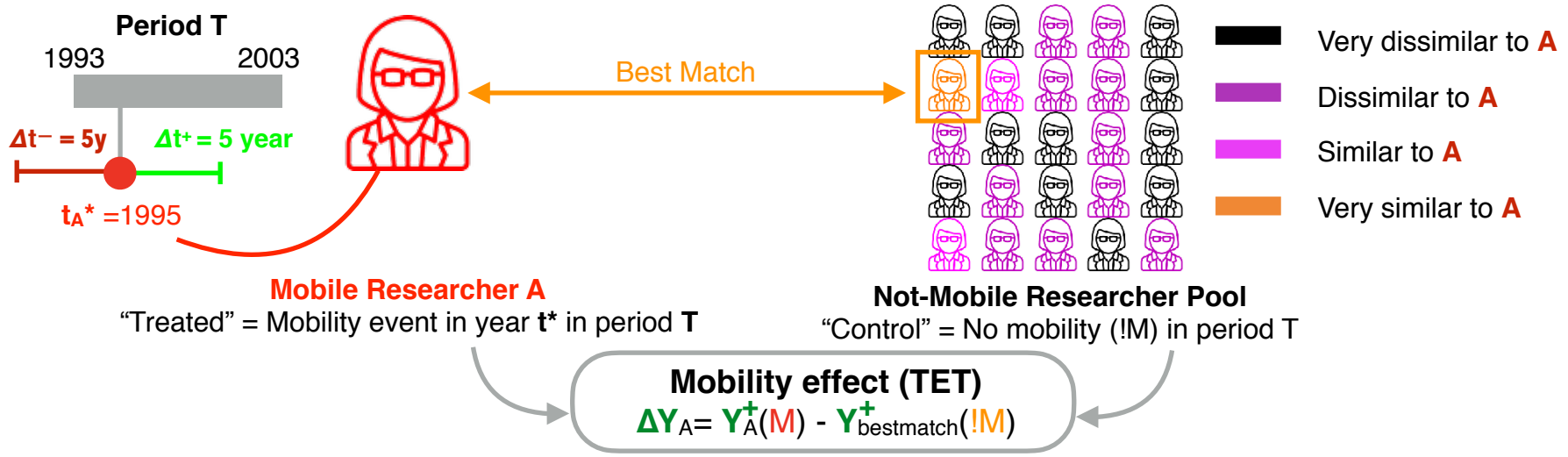
● **G3 = Treatment Group** = Moved in T
G1 = Control = Never-moved

"Placebo" model - comparing researchers that were not mobile (!M) in **T**

Treatment model - comparing Mobile to Not-Mobile researchers in **T**



Counterfactual matching method — compare each mobile researcher with the most similar non-mobile researcher and compute difference in **outcome variable Y** ↦ estimation of **"treatment effect on treated" (TET)**

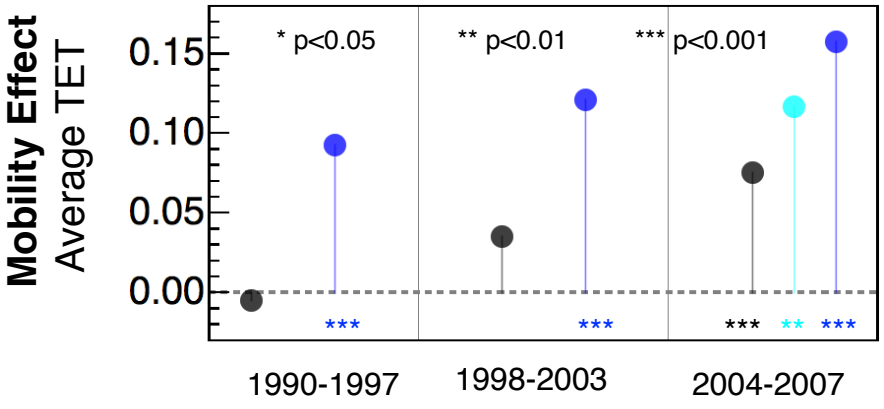


● **Treatment Group =** Moved < T
Control Group = Never-moved

● **Treatment** = Moved in T
Control = Moved < T

● **Treatment Group** = Moved in T
Control = Never-moved

Y = Z^+ **=** (Log-Normalized) Mean Citation Impact



$$z_{p,i} = \frac{\ln(1 + c_{p,i,t}) - \mu_t}{\sigma_t}$$

$$Z_i^+ \equiv \langle z_{p,i}^+ \rangle = (1/N_i^+) \sum_{p \in N^+} z_{p,i}^+$$

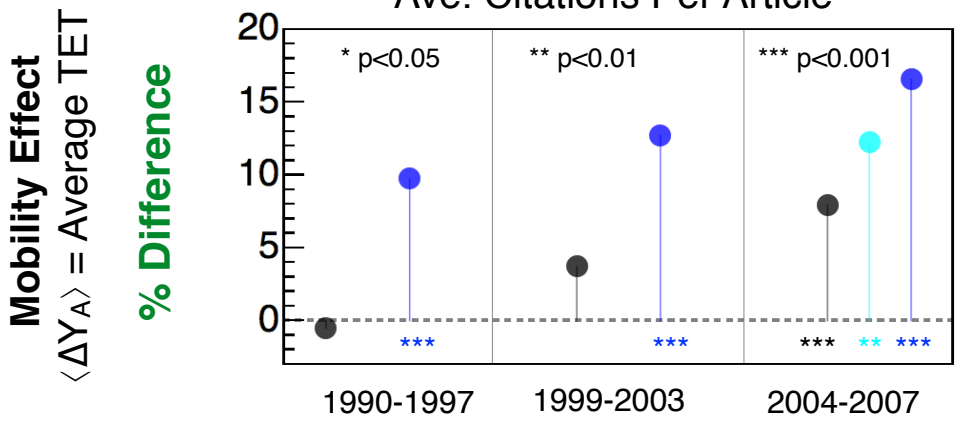
Cross-Border Mobility effect:

Relative to non-mobile researchers that are similar in research profile attributes prior the mobility event

— Mobile researchers gain up to a 10-17% increase in citations corresponding to ~100 **APS** citations….

Outcome Measure Y =

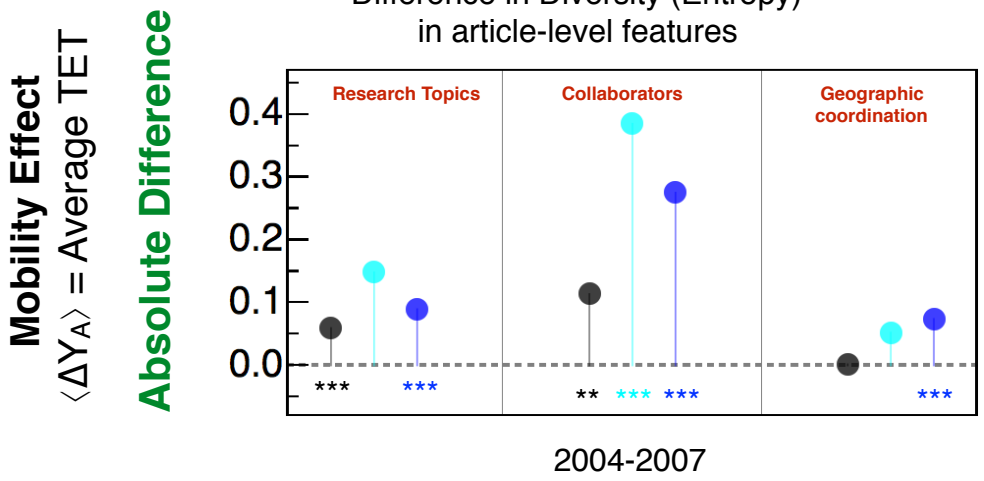
Ave. Citations Per Article



…. Coincident with higher diversity of research topics & collaborators & geographic coordination

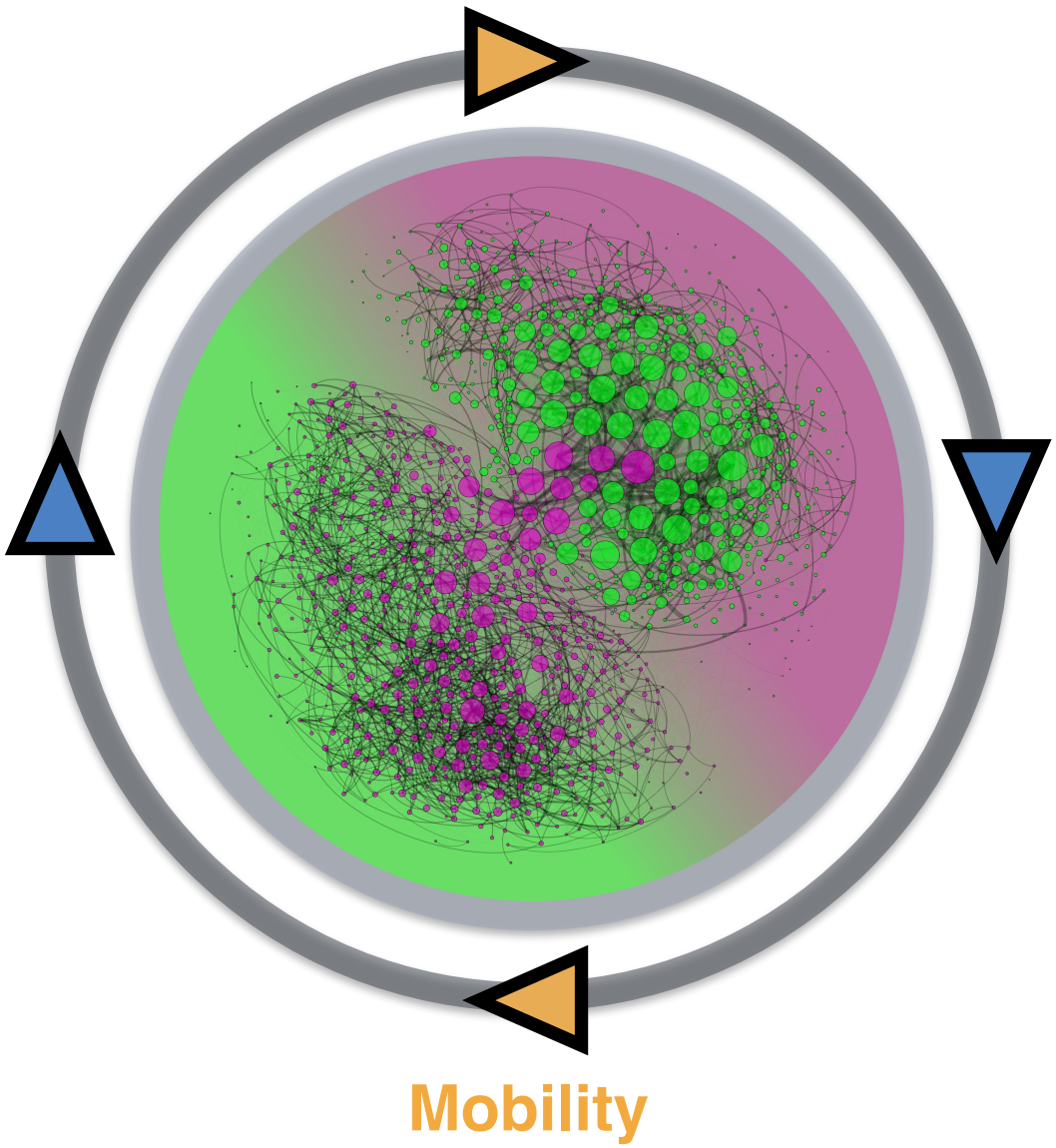
Outcome Measure Y =

Difference in Diversity (Entropy)
in article-level features



Multiscale Impact of Researcher Mobility — Journal of the Royal Society Interface (2018)

Part 3 — Coevolution of Collaboration & Mobility



European Research Area (ERA) — a cross-border labor, funding, and mobility scheme aimed at fostering innovation and growth across Europe

?

Which map is more representative of the ERA according to **cross-border collaboration**

?

National borders

EU borders

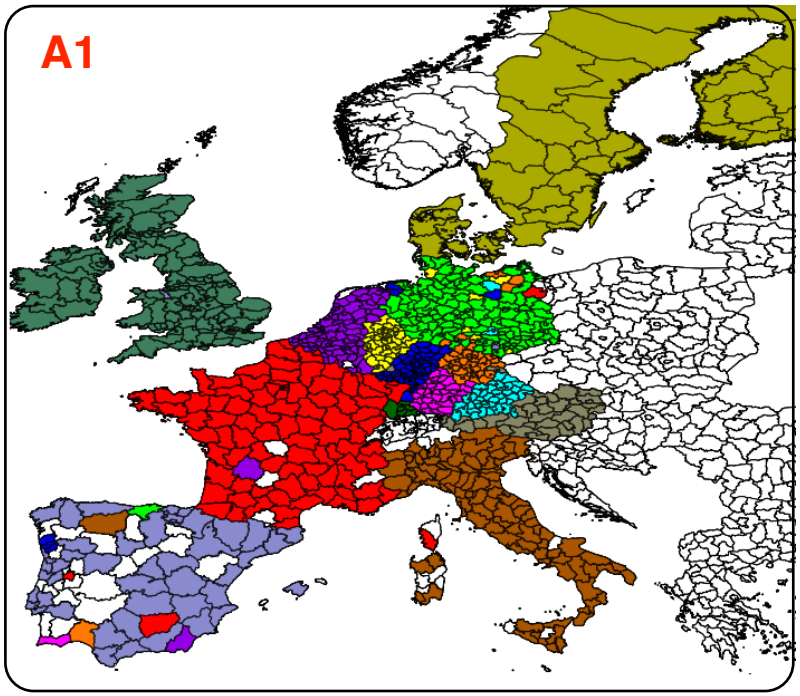
Data: 2.4 million patents filed at the EPO ↦ Co-inventor & Inventor mobility networks

Is Europe Evolving Toward an Integrated Research Area? — Science (2013)

Q1 - Structurally: Are the ERA R&D borders integrated beyond geo-political borders?

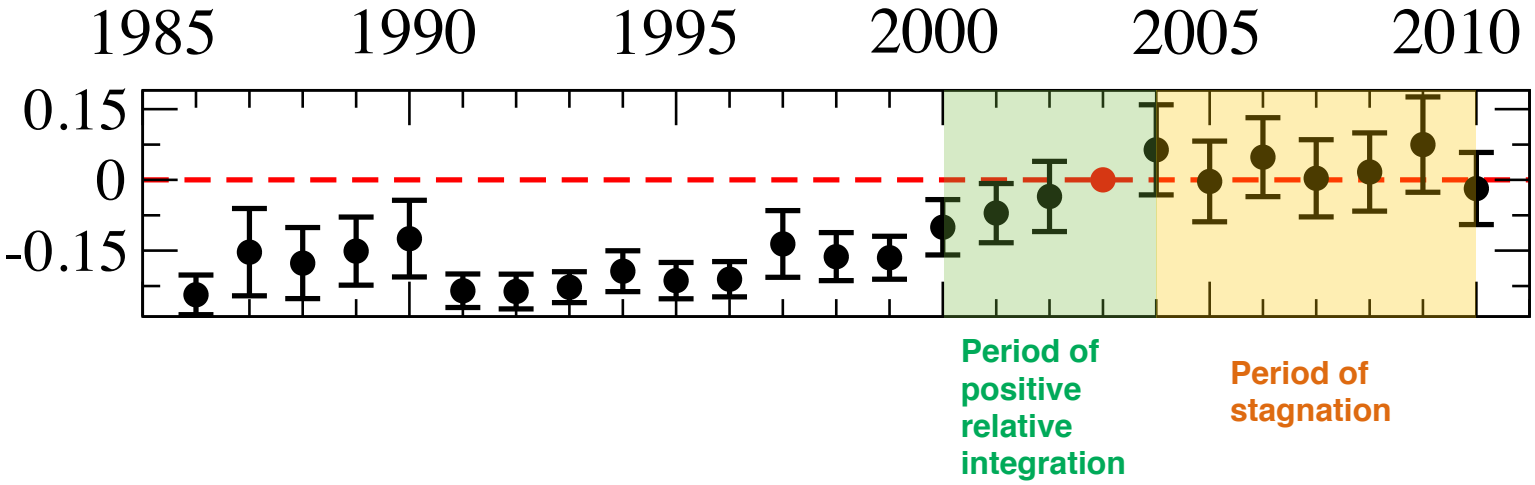
Q2 - Temporally: has there been an intensification in cross-border R&D activity in Europe — i.e. evidence for integration

A1



A2

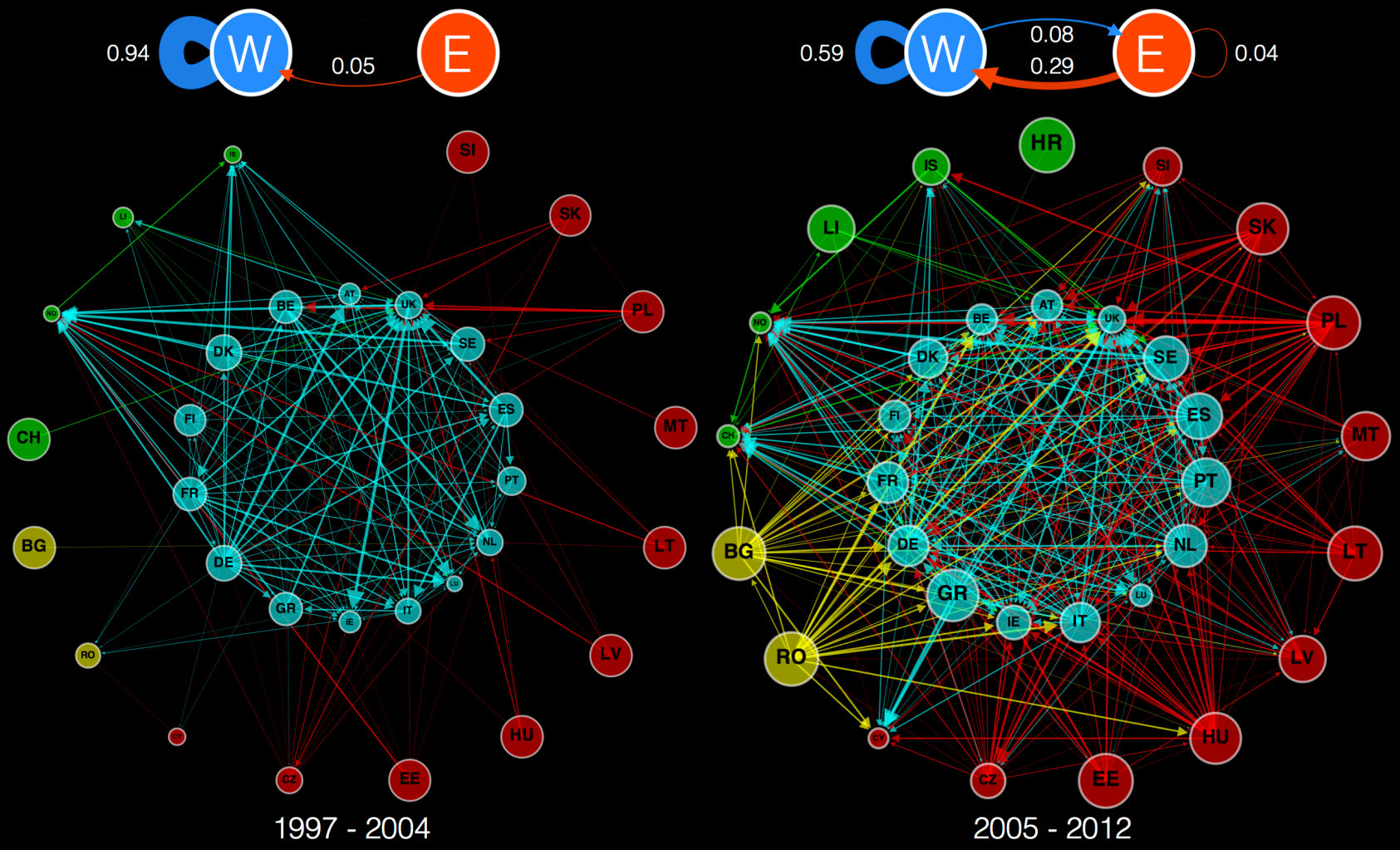
EU Integration
change in cross-border links due to EU-specific factors



Why stagnation since ~2004???

In this analysis we incorporate a key factor:

'***Brain drain***' — *Asymmetric Migration* — largely from Eastern to Western European countries



EU Enlargement: useful for identifying an important mechanism connecting:

the formation of international social capital (cross-border collaboration) and **the flow** of human capital (migration)

Quantifying the negative impact of brain drain on the integration of European science — Science Advances (2017)

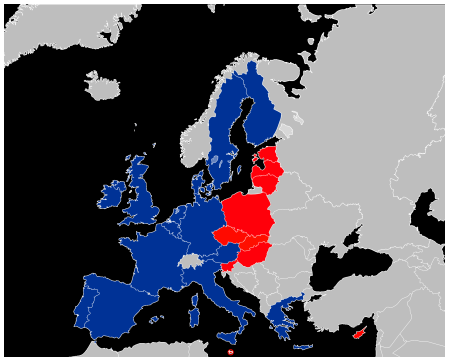
High-skilled labour mobility in Europe before and after the 2004 enlargement — J Royal Society Interface (2017)

Objective: use the Synthetic Control Method (SCM) to **estimate cross-border collaboration rates** in Europe under the counterfactual — no 2004/07 EU enlargement

SCM: Abadie et al., *American Economic Review* **93** (2003); Abadie et al., *J. Amer. Stat. Assoc.* **105** (2010)

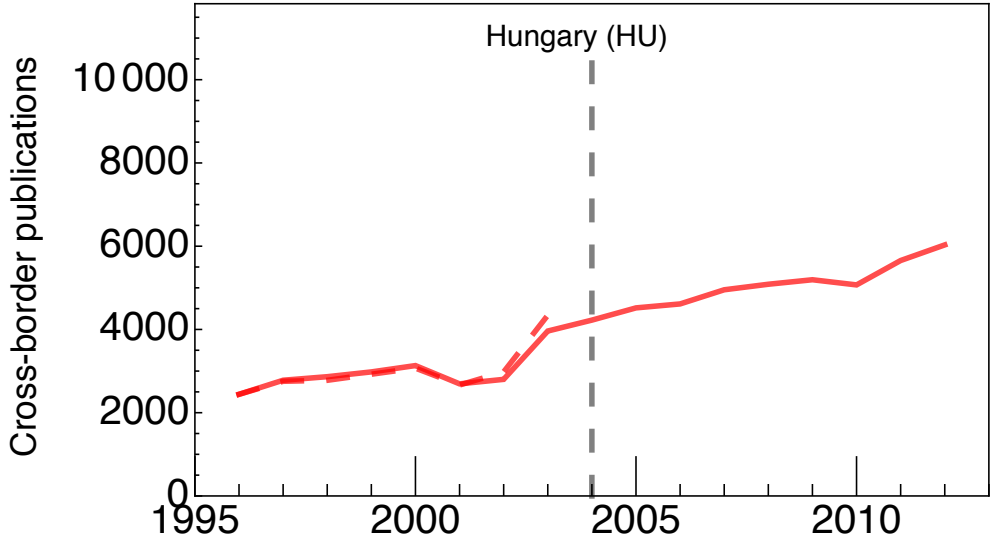
Pre-existing 2004 EU

New 2004 EU



26 non-EU control group countries:
AR, AM, AZ, BY, CA, CN, CO, CU, IN, IL, JP, KZ, KW, KG, MG, MX, MN, PA, RU, RS, SG, KR, TT, TR, UA, US

Country-level control/matching variables:
[Scimago] Cross-border pubs, Total pubs, Citations
[World Bank] GDPpercapita, Govt. Expenditure on R&D



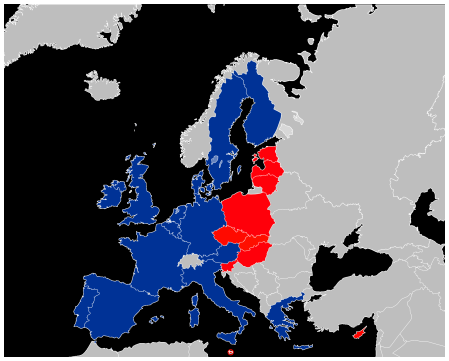
Counter-intuitive consequences of the 2004/2007 EU Enlargement

Objective: Estimate cross-border collaboration rates in Europe under the counterfactual — no 2004/07 EU enlargement — using the Synthetic Control Method (SCM)

SCM: Abadie et al., *American Economic Review* **93** (2003); Abadie et al., *J. Amer. Stat. Assoc.* **105** (2010)

Pre-existing 2004 EU

New 2004 EU



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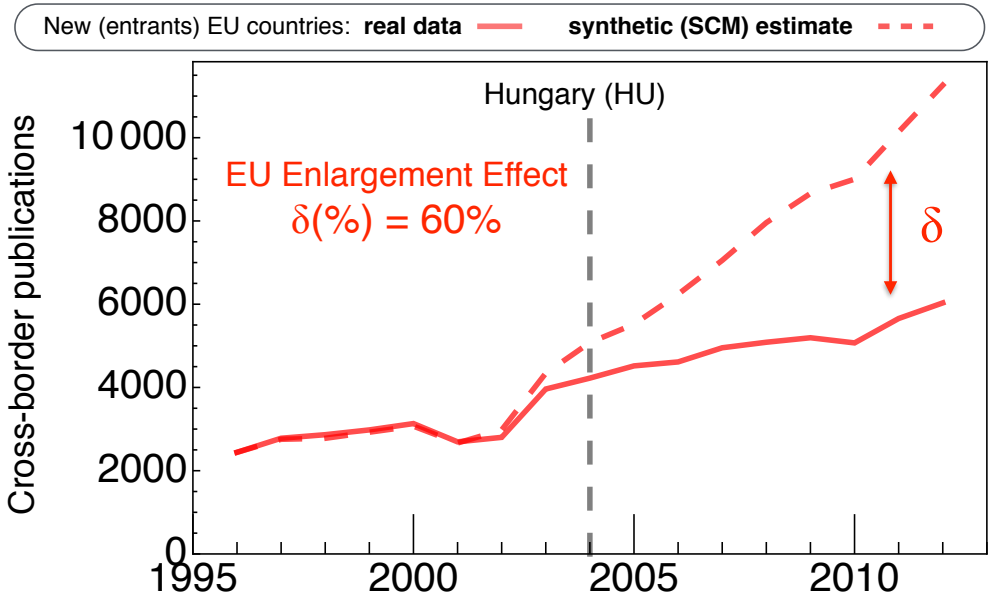

11 of 12 Countries show negative impact of EU enlargement on cross-border collaboration (fraction of total publications AND total publication volume)

BG, CZ, EE, HU, LT, LV, MT, PL, RO, SI, SK

$\delta(\%) > 0$

$\delta(\%) < 0$

1 Country shows positive impact: **CY**

Results indicate more cross-border integration among EU entrants — if there had been **no EU enlargement**!

— When scientists cross ***controversial*** lines —

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Regular article

Megajournal mismanagement: Manuscript decision bias and anomalous editor activity at PLOS ONE

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nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-019-09959-4 OPEN

Discrepancy in scientific authority and media visibility of climate change scientists and contrarians

Alexander Michael Petersen [1], Emmanuel M. Vincent[2,3] & Anthony LeRoy Westerling[1,3,4]

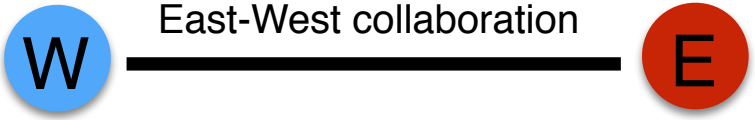
A mobility-mediated collaboration dis-integration mechanism

Brain drain: largely from Eastern to Western European countries

1997-2004 2005-2013

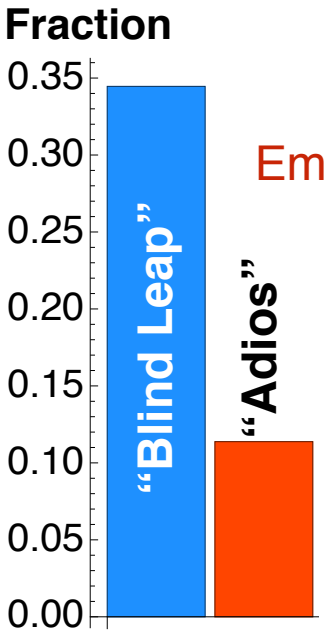
Mechanism connecting Cross-border Collaboration & Mobility

Before 2004 EU enlargement



After 2004 EU enlargement

Cross-border link eliminated



Empirical evidence from analysis of ~ 27,000 researcher mobility events

⟸ **Fraction of mobility events** in which there is no overlap between past and future researcher location.

"Blind Leap" mobility (34%): researcher does not follow previous collaboration channel $C^+ \cap c_i^- = 0$

"Adios" mobility (11%): researcher does not maintain any previous collaborations $C^- \cap c_i^+ = 0$

Thanks for your attention!

… and also thanks to my esteemed collaborators in these works

Fabio Pammolli (Milano Politecnico), Ioannis Pavlidis (U. Houston), Orion Penner (EPFL)

Petersen, Majeti, Kwon, Ahmed, Pavlidis — **Cross-disciplinary evolution of the genomics revolution** Science Advances (2018)

Petersen — **Multiscale impact of researcher mobility** J. Royal Society Interface (2018)

Doria, Pammolli, Petersen — **Quantifying the negative impact of brain drain on the integration of European science** Science Advances (2017)

Petersen, Puliga — **High-skilled labour mobility in Europe before and after the 2004 enlargement** J. Royal Society Interface (2017)

Chessa, Moreschalci, Pammolli, Penner, Petersen, Riccaboni — **Is Europe evolving toward an integrated research area?** Science (2013)

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