

Rooted America: Immobility and Segregation of Inter-county Migration Networks

Peng Huang

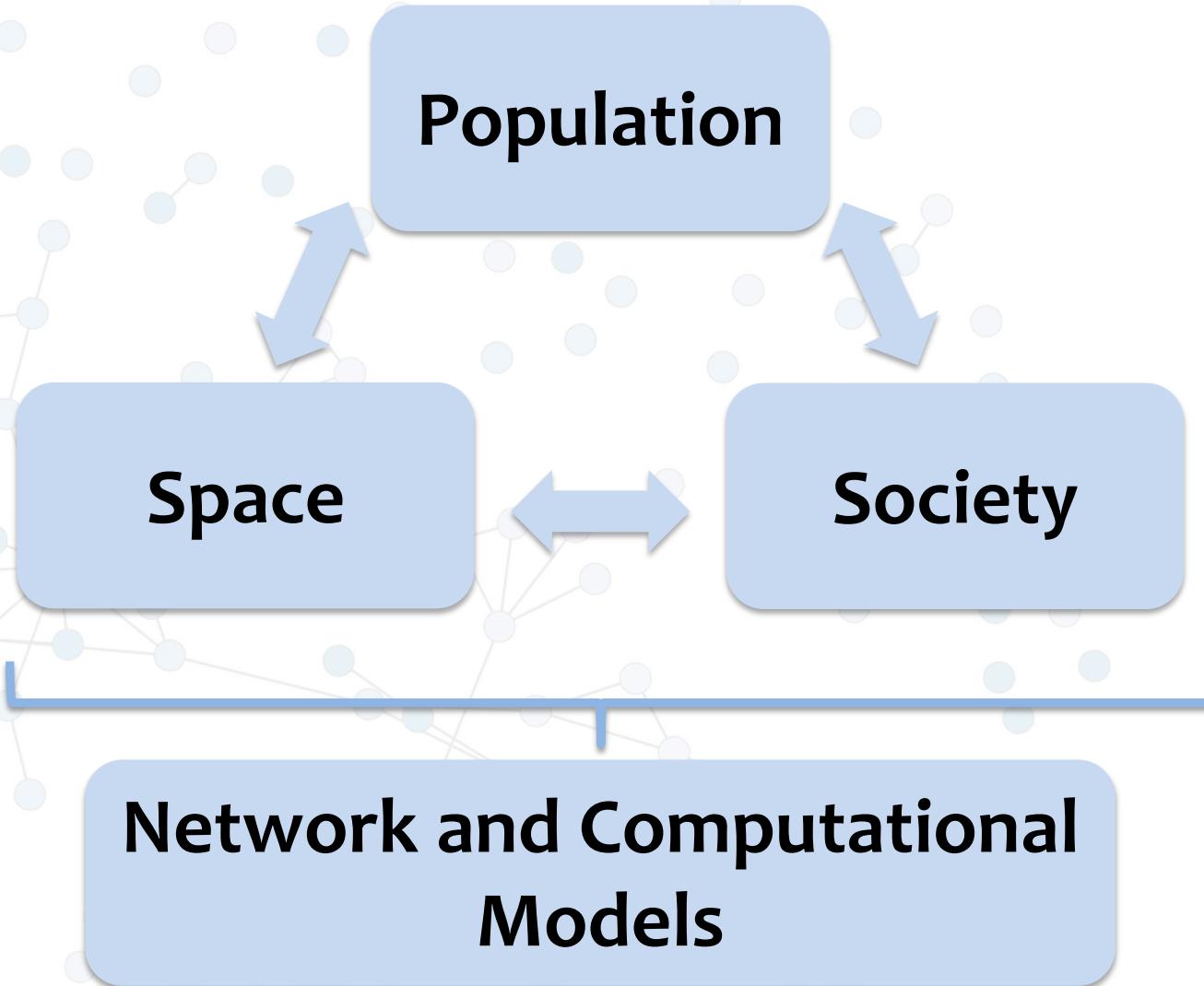
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Research Profile

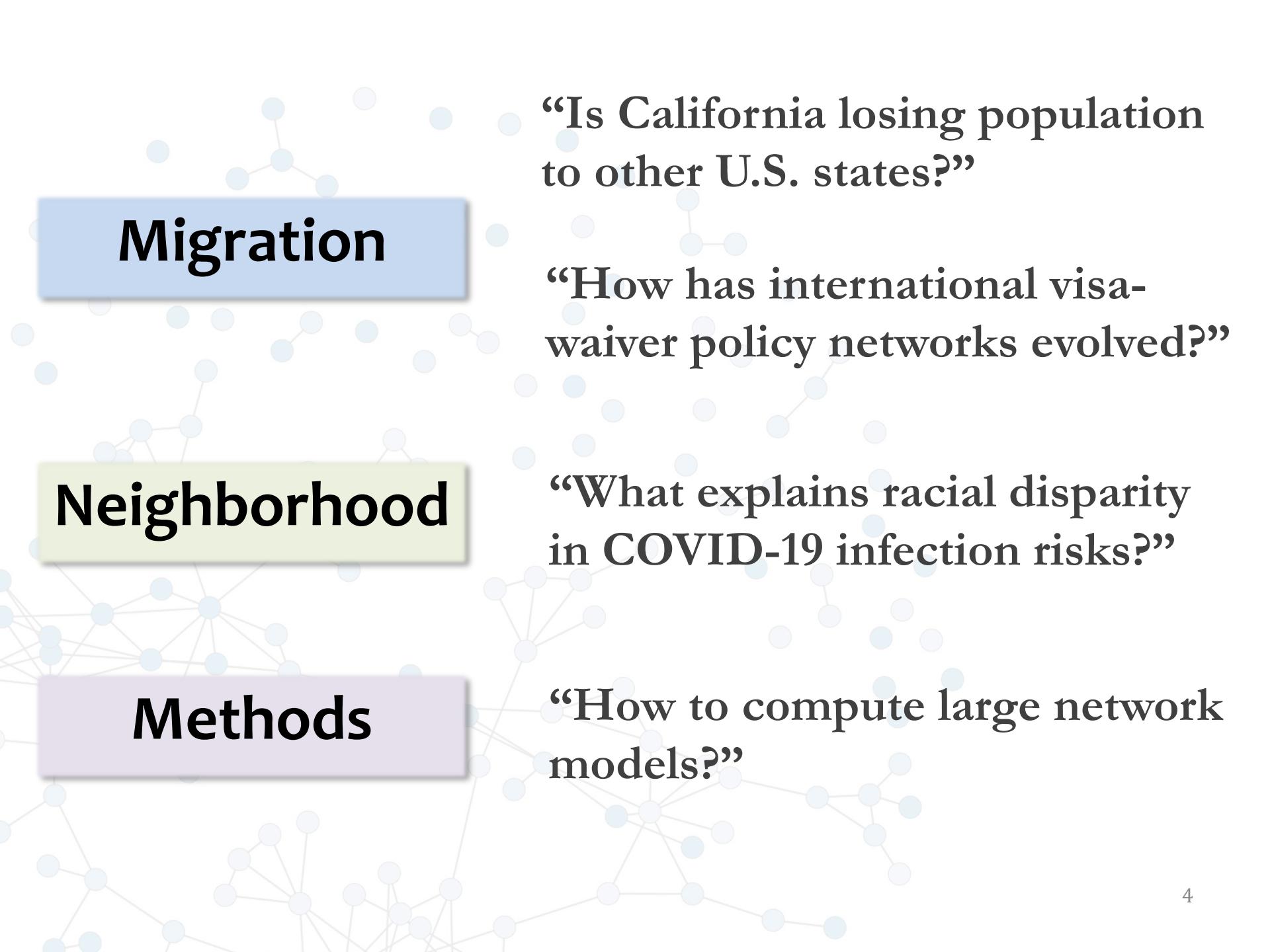


Research Profile

Migration and demographic change

Neighborhood and population health

Methods for large-scale dynamic data



Migration

“Is California losing population
to other U.S. states?”

Neighborhood

“How has international visa-
waiver policy networks evolved?”

Methods

“What explains racial disparity
in COVID-19 infection risks?”

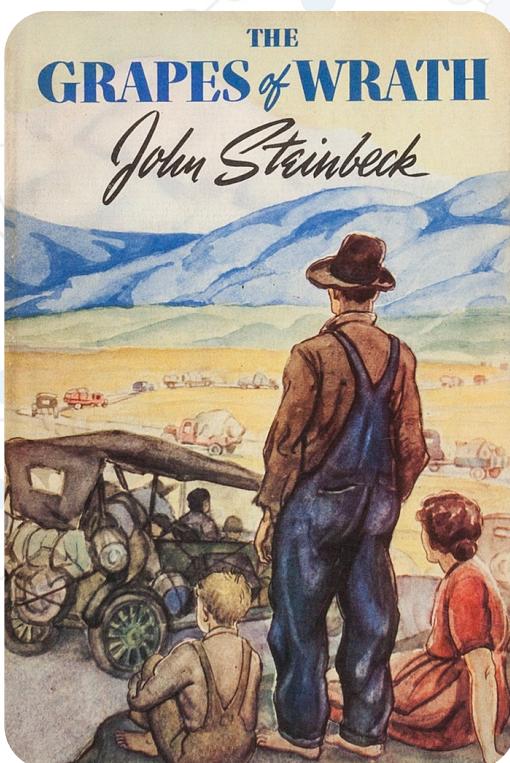
“How to compute large network
models?”



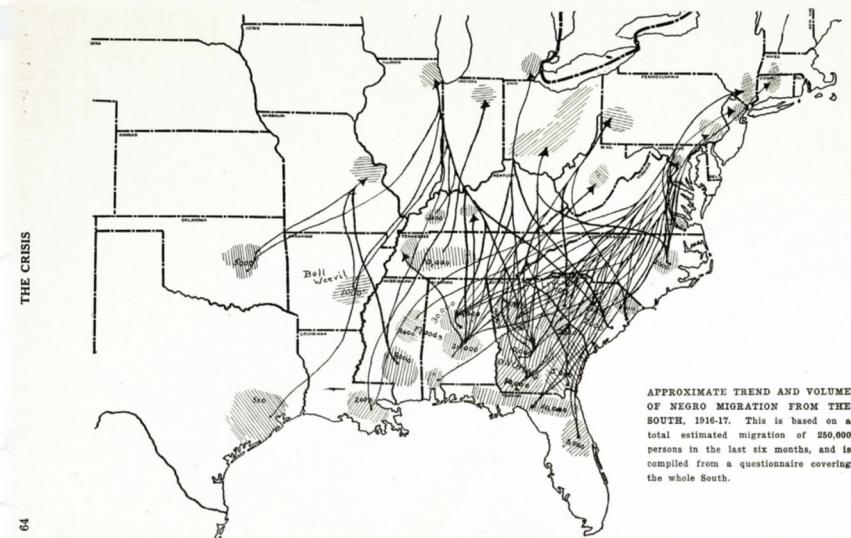
“Americans today are
not migrating. Why?”

America: a rootless society

Migration from
the Dust Bowl



The Great Migration of
African Americans



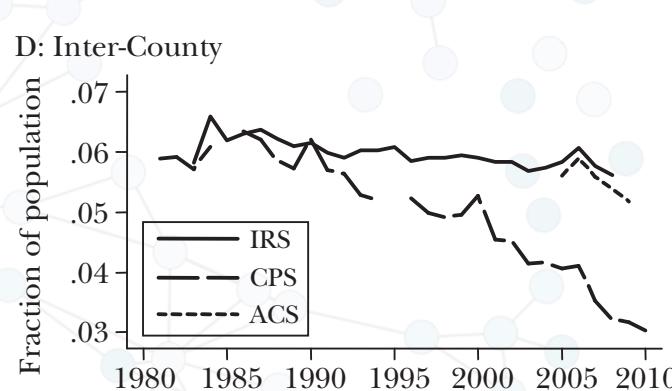
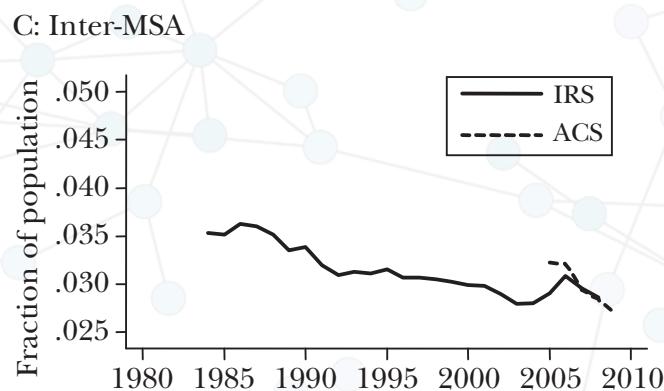
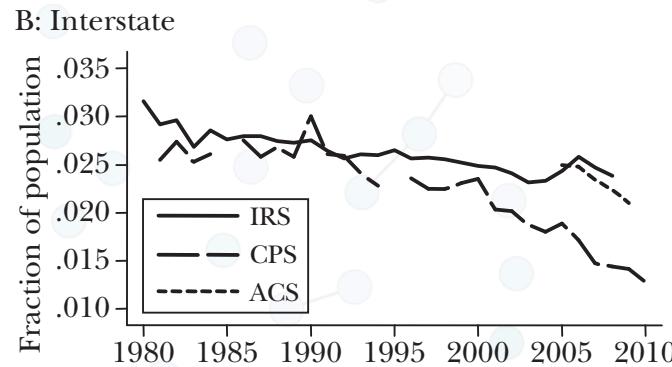
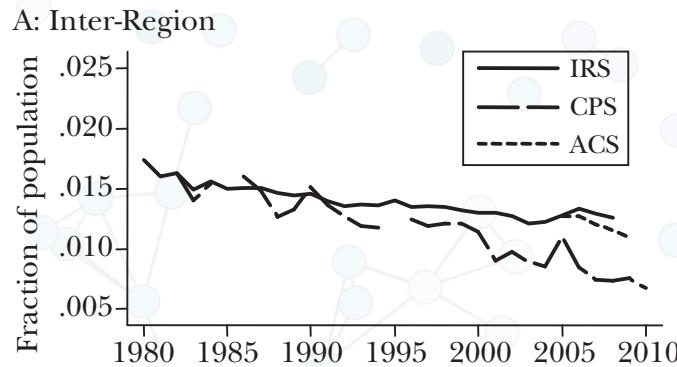
By W. E. B. DuBois (1917) in *The Crisis*

Moving within America

Americans today don't move

Why?

Annual Internal Migration Rates



Source: Molloy, Smith, and Wozniak 2011

What influences migration?

- Migration is a **demographic** phenomenon
 - life-course event
 - age matters, marital status matters, etc.
- Migration is an **economic** phenomenon
 - migration happens when it brings net profit (Todaro 1976)
 - job opportunities, living costs matter, etc.

They do not explain this immobility

- Researchers found little supporting evidence that the low migration rate can be explained by (e.g., Hyatt and Spletzer 2013; Hyatt et al. 2018; Molloy et al. 2011, 2017):
 - demographic and socioeconomic structures of population
 - labor market composition
 - housing market properties
 - others: occupational licensing, health-insurance retention

Puzzle: What inhibits migration?

- “Mobility bias” in migration studies (Schewel 2020)
- Social scientists have studied extensively about what drives migration (financial, social, political capital etc.)
- Much less is known about what inhibits migration

Puzzle: What inhibits migration?

- Study case: U.S. internal migration in 2011-5
- Move beyond demographic and economic factors
 - a comprehensive survey of the social institutions that influence migration
- Reflect on the analytic framework of migration research
 - how shall we study migration

What influences migration...

besides demographic and economic factors?

what is the most *you* thing you've ever done? for me,
a real contender for that title is that as i've been
looking at houses (~thoughts and prayers~), i've been
cross-referencing them with voting precincts results
from the last four elections to make sure i can live
there



11:12 AM · Mar 29, 2022 · Twitter Web App

Migration is a political phenomenon

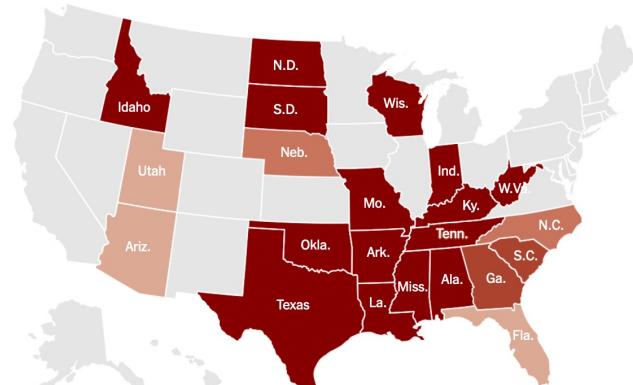
- People vote with their feet
 - public choice theory and consumer-voter model (Dye 1990; Tiebout 1956)
- Sub-national Policy
 - economic policy such as tax policy
 - education expenditure
 - women's rights such as abortion right

SPENDING PER STUDENT, BY SCHOOL DISTRICT *Average annual taxes paid, 2007-2011, as share of income*

Tracking Abortion Bans Across the Country

By The New York Times Updated Aug. 23, 11:30 A.M. ET

■ Full ban ■ Six weeks ■ 12 weeks ■ 15-18 weeks



Interactive by Christopher Ingraham

Data from IRS Statistics of Income.

Source: Brookings Institute

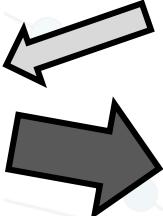
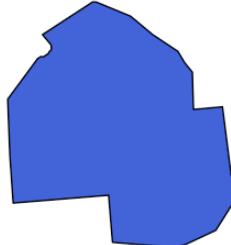
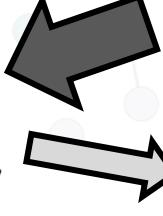
Credit: Alyson Hurt and Katie Park/NPR (2016)

Migration is a political phenomenon

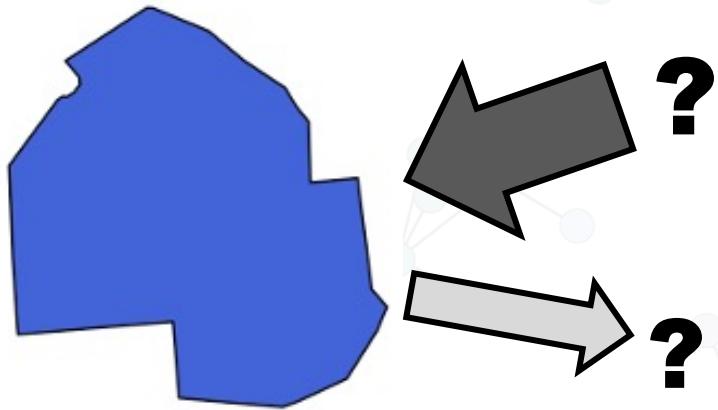
- Local political climate
 - Spillover effects of policy: e.g., immigrant policy affects the sense of belonging of Latinos, including U.S.-born Latinos (Schildkraut et al. 2019)
 - Political ideology as place-based social identity (Cramer 2016; Hochschild 2018)
 - Homophily (McPherson et al. 2001)
- Claim: people stay in and migrate towards places that match their political leanings

Analytical Approach

- How to study migration as a political phenomenon?
- Correlates migration patterns of a place with its political climate (e.g., Preuhs 1999)

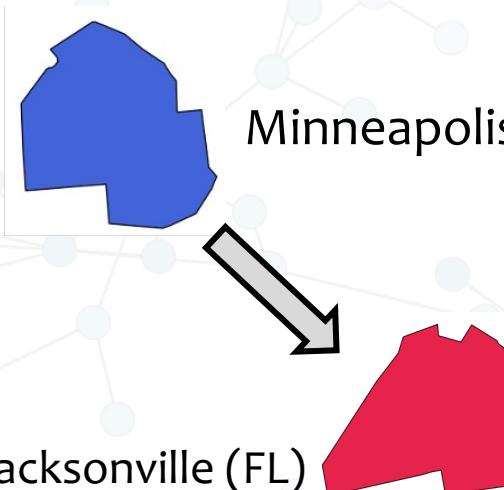
Orange, CA	Hennepin, MN	...
 	 	...
Obama receives 47.6%	Obama receives 63.4%	...
Net migration -11,050 -0.3%	Net migration -1,088 -0.1%	...

Analytical Approach

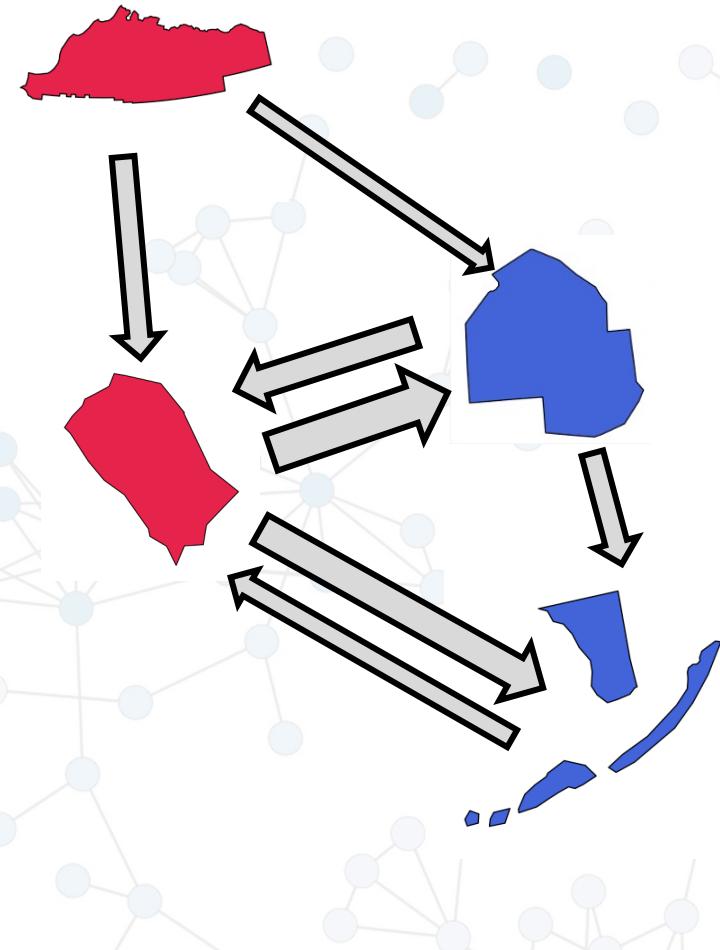


- Study immigration without knowing the origin
- Study emigration without knowing the destination
- Viewing migration as a characteristic of a place divides migration into two separated processes: im-migration and e-migration

Analytical Approach

- Migration, people moving from one place to another, is a *relational* phenomenon
 - The relational approach shifts the analytical unit from a place to a pair of places
 - We consider how the origin and destination jointly influences migration between them
- 

Migration Systems

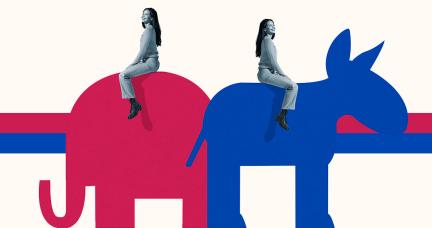


- Migration flows between places form an interconnected system (migration systems theory: DeWaard & Ha 2019; Mabogunje 1970)
- Migration flow network
 - counties (nodes)
 - migration flows (edges)
 - RQ: what explains the magnitudes of migration flows between counties

Political Polarization

- The relational view puts in context the political polarization across geography:
 - Political polarization has divided Americans along party lines, spatially

“A large proportion of voters live with virtually no exposure to voters from the other party in their residential environment” (Brown & Ethos 2021)



Source: yes magazine

Political Polarization

- Political polarization is not only spatial, but also affective:
 - Americans today regard people from the other party with suspicion and hostility (Iyengar et al. 2019)
- Migration is less likely to happen across party lines
- *H1: the more dissimilar counties are in their political climate, the less the migration flow between them.*

Segmented Immobility

- The relational view reveals connection between segmentation & immobility
 - Segmentation across geography in their social environments (e.g., political climate)
 - Tendency of avoiding boundary crossing
- Segmented immobility: limited population exchange between geographical segments with dissimilar social environments

Segmented Immobility

- Rural-urban division:
 - H2: *the more dissimilar counties are in their levels of urbanization, the lower the migration flow between them.*
- Racial segregation:
 - H3: *the more dissimilar counties are in their racial compositions, the lower the migration flow between them.*

Data and Variables

- Predict migration flows
 - annual count of migrants between all directed pair of the 3,142 counties in 2011-2015
 - from the American Community Survey (ACS)

Data and Variables

- Effects of segmented immobility
 - Political dissimilarity: absolute difference in % Democratic votes in 2008 presidential election
 - Rural dissimilarity: absolute differences in % of urban population in 2010
 - Racial dissimilarity: dissimilarity score of racial compositions in 2010

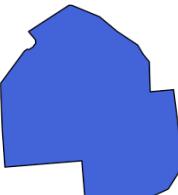
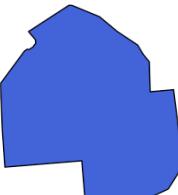
$$R_{AB} = \frac{1}{2} \sum_{i=1}^n \left| \frac{P(A)_i}{P(A)} - \frac{P(B)_i}{P(B)} \right|$$

Data and Variables

- Control covariates (2010 Census, 2006-10 ACS)
 - international immigrant inflows
 - demographic: population size and density, age structure, origin racial composition
 - economic: homeownership %, higher-ed %, unemployment rate, housing costs
 - geographic: distance, same state, region fixed effects

Methods

- Exponential-family random graph models (ERGMs) for valued networks (Krivitsky 2012)
- **Roughly** a generalization of Poisson regression

Orange, CA → Hennepin, MN	Hennepin, MN → San Diego, CA	...		
 → 	 → 	...		
Political dissimilarity	15.8%	Political dissimilarity	9.27%	...
Migrant count	120	Migrant count	362	...

Methods

- Challenge 1: it is not a regression
 - “autocorrelation”: migration flows correlate with each other
 - e.g., OC->Clark & Clark->OC
 - theoretical insights about the migration systems: “internal dynamics” (de Haas 2010)
 - theorize, formalize, and measure the internal dynamics in network analysis (more in the paper)

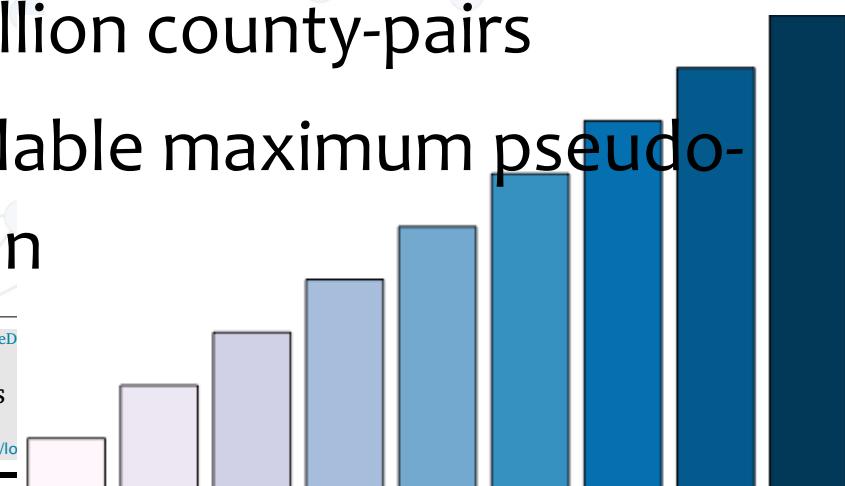
Methods

- Challenge 2: very difficult to compute
 - network analysis mostly focuses on binary social relations; valued network analysis less developed
 - big network: 9.9 million county-pairs
 - subsampled parallelable maximum pseudo-likelihood estimation



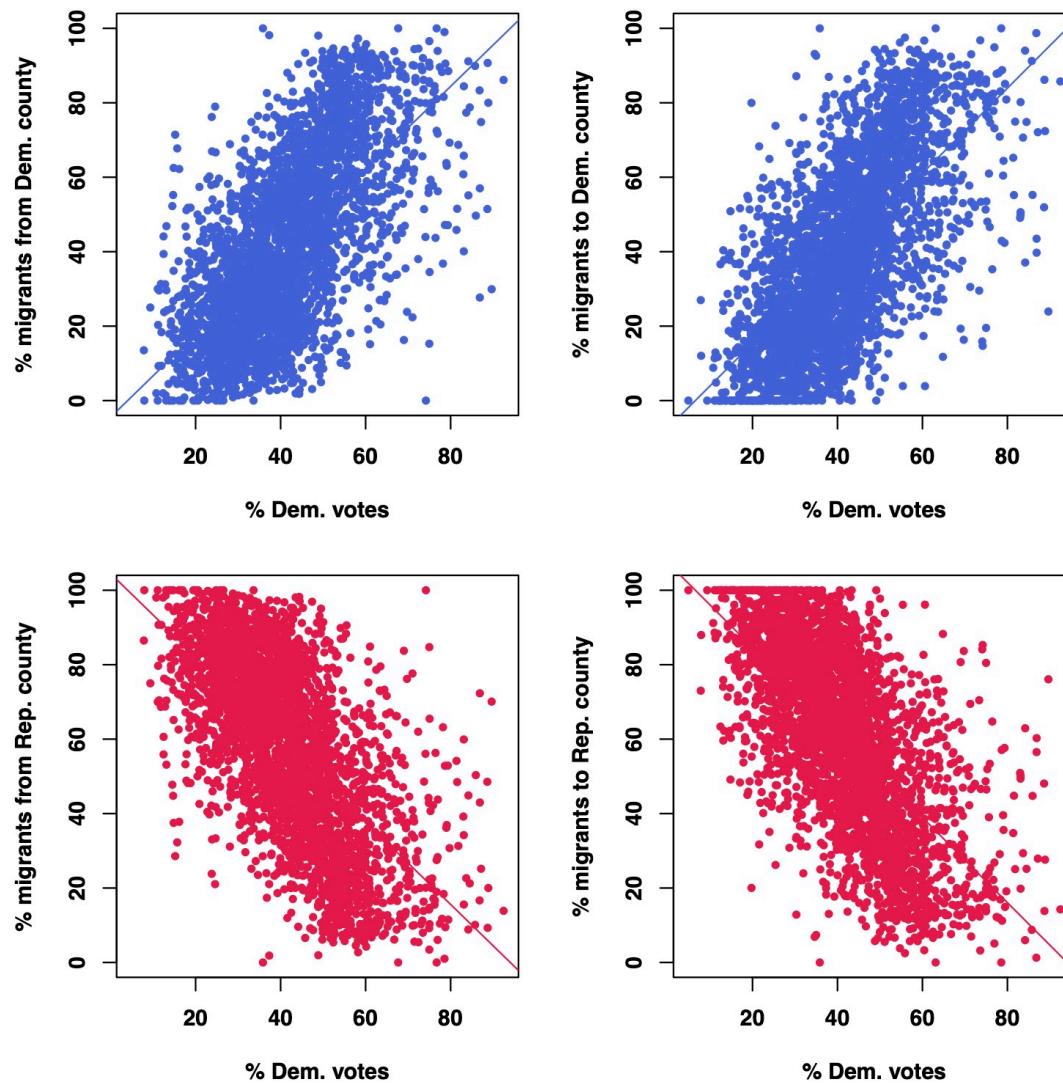
models on count-valued networks: A comparative simulation study

Peng Huang^a, Carter T. Butts^{a,b,*}
Binary

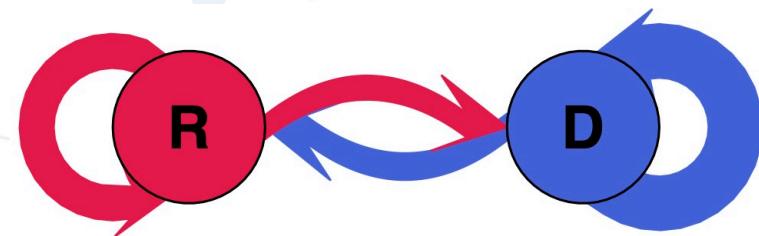


Valued

Immobility from political division



Counties with higher democratic voter share receives more migrants from a blue county and sends more migrants to a blue county



Inter-county Migration Flows 2011-15

	Estimate	Std.Err
<i>Segmented Immobility</i>		
Political dissimilarity	-0.256 ***	0.007
Rural dissimilarity	-0.399 ***	0.004
Racial dissimilarity	-0.217 ***	0.006
<i>Control Covariates</i>	(included)	

Note: *** $p < 0.001$ (two-tailed tests)

Segmented Immobility

people are less likely to migrate when it involves crossing a boundary towards a distinct socio-political environment

Knockout experiment

- **How much does segmentation contribute to immobility?**
- A counterfactual scenario where segmentation does not influence migration
- Knock out the effects (coefficients), and simulate

	Estimate
Segmented Immobility	
Political dissimilarity	0
Rural dissimilarity	0
Racial dissimilarity	0

- Compare total number of inter-county migrants in counterfactual scenarios to the observed

Knock-out Experiments

	Total Migrants	Diff. in # and rate	
Observed	17,176,675		
\ political segmentation	17,965,336	+788,661	+4.6%
\ all segmentation	21,741,021	+4,564,346	+26.6%

In a world without segmented immobility,
there would be 26.6% more inter-county migrants,
4.6 million more people moving from one county
to another each year.



11x



15x

Conclusion

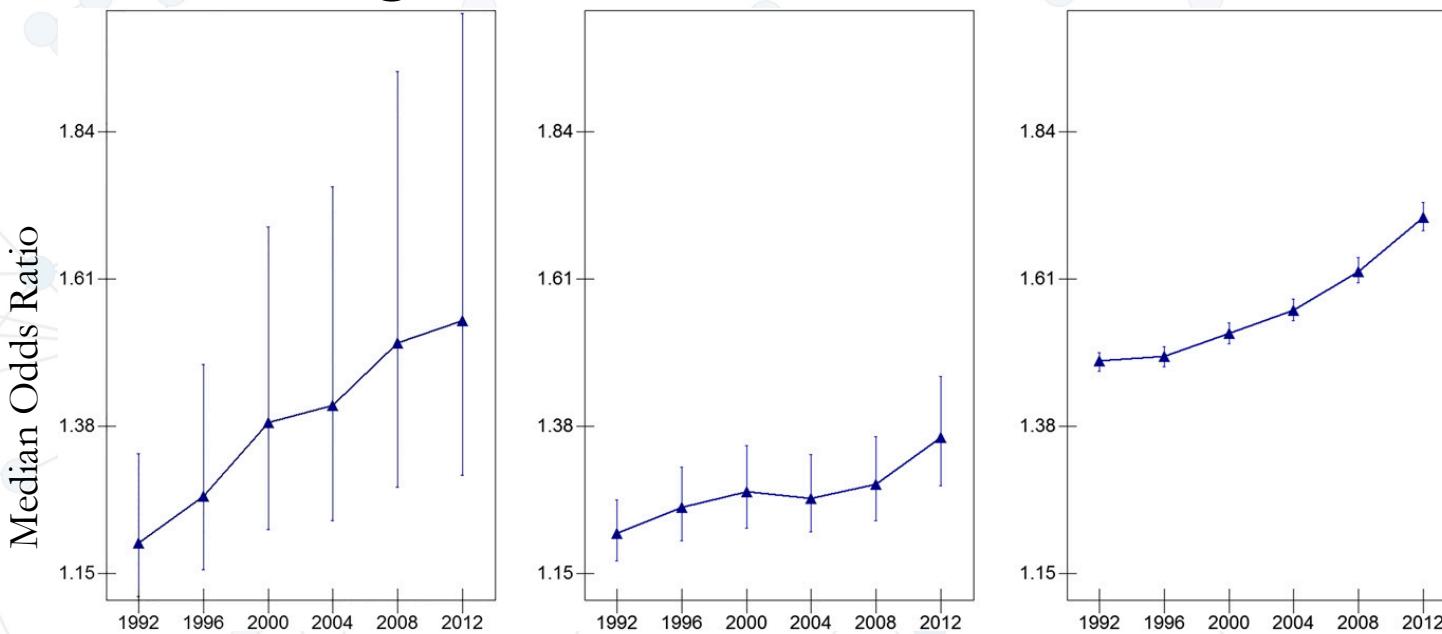
- A relational analysis of inter-county migration flow system offers new insights about immobility
- Segmented immobility: migration is suppressed between counties with dissimilar political environments, levels of urbanization, and racial compositions
- A pattern that could potentially hinder millions of people from migrating each year based on knockout experiments

Discussion

- Segmented immobility suggests a limited population exchange between communities with different cultural, political, and racial environments
- Not only a mechanism of **immobility**
- But can also lead to **segregation** and **polarization** of people with different identities and/or beliefs (Fossett 2006; Sakoda 1971; Schelling 1969)
- There exists an intrinsic relationship among **immobility, segregation, and polarization**

Next Steps

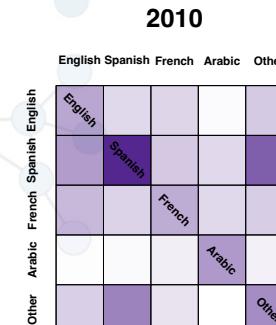
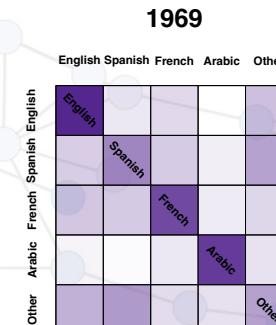
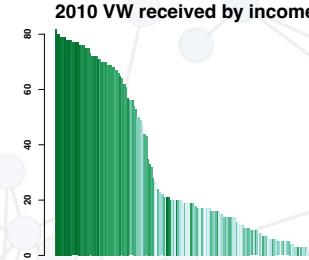
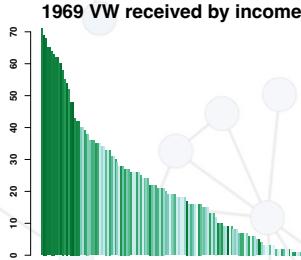
- Longitudinal analysis: growing immobility & political polarization
 - ACS migration flow data starts in 2006



Political polarization at the county, state, and division levels (Johnston et al. 2016)³⁵

Future Projects

- Post-pandemic internal migration
- International visa-waiver policy network
 - stratification of global migration opportunities
- Global migration flow system
 - climate change and political violence
 - short-term and long-term impacts via simulation



Thank you

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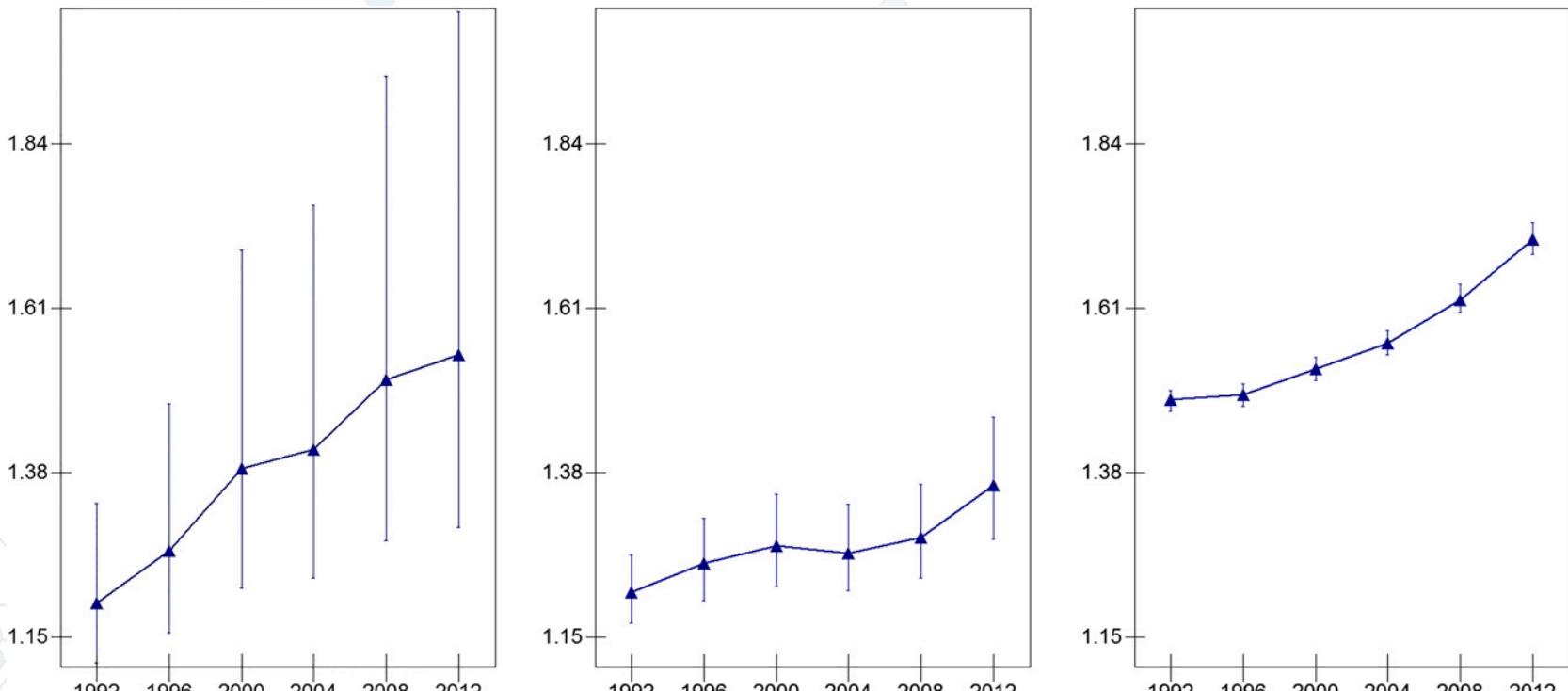
NETWORKS, COMPUTATION, and SOCIAL DYNAMICS

University of Minnesota

Fall 2023

UCI University of California, Irvine

Change of political geography



Median odds ratios at the county, state, and division levels (Johnson et al. 2016)

Political Polarization has grown stronger across geography at three spatial scales

Full Model

Inter-county Migration Flows 2011-15

	Estimate	Std.Err
<i>Network patterns</i>		
Reciprocity	0.045 ***	0.002
Log(past migrant flow)	0.300 ***	<0.001
Waypoint flow	-0.015 ***	0.001
<i>Control Covariates</i>		

Note: *** $p < 0.001$ (two-tailed tests)

- Significance of internal dynamics of the migration flow system
- Strong patterns of reciprocity and perpetuation
- A suppression of waypoint structure
(implications on the scale of chain-like migration)

Inter-county Migration Flows 2011-15

	Estimate	Std.Err
Demographics		
Destin.log(immigrant inflow)	0.056 ***	0.001
Origin.log(immigrant inflow)	0.035 ***	0.001
Destin.log(population size)	0.351 ***	0.002
Origin.log(population size)	0.373 ***	0.001
Destin.log(population density)	-0.083 ***	0.001
Origin.log(population density)	-0.069 ***	0.001
Destin.PSR	0.017 ***	0.001
Origin.PSR	0.013 ***	0.001

Note: *** $p < 0.001$ (two-tailed tests)

$$\text{PSR (potential support ratio)} = \frac{\text{Population (age 15~64)}}{\text{Population (age 65+)}}$$

Inter-county Migration Flows 2011-15

	Estimate	Std.Err
<i>Origin racial demographics</i>		
Origin.P(White)	(reference group)	
Origin.P(Hispanic)	-0.064 ***	0.007
Origin.P(Black)	0.117 ***	0.008
Origin.P(Asian)	-0.467 ***	0.020
Origin.P(other race)	0.993 ***	0.015
<i>Baseline</i>		
Sum	-1.193 ***	0.040
Nonzero	-13.917 ***	0.028

Note: *** $p < 0.001$ (two-tailed tests)

Inter-county Migration Flows 2011-15

	Estimate	Std.Err
Economics		
Destin.P(renter)	0.348 ***	0.011
Origin.P(renter)	0.476 ***	0.012
Destin.P(higher education)	0.359 ***	0.011
Origin.P(higher education)	0.153 ***	0.012
Difference.log(housing costs)	-0.153 ***	0.004
Origin.log(housing costs)	-0.277 ***	0.005
Difference.P(unemployment)	-1.300 ***	0.040
Origin.P(unemployment)	-3.012 ***	0.052

Note: *** $p < 0.001$ (two-tailed tests)

Inter-county Migration Flows 2011-15

	Estimate	Std.Err
Geographics		
Log(distance)	-0.568 ***	0.001
Same state	0.510 ***	0.002
Northeast	(reference group)	
Destin.South	0.253 ***	0.003
Origin.South	0.046 ***	0.003
Destin.West	0.374 ***	0.004
Origin.West	0.184 ***	0.004
Destin.Midwest	0.197 ***	0.003
Origin.Midwest	0.080 ***	0.003

Note: *** $p < 0.001$ (two-tailed tests)

Inter-county Migration Flows 2011-15

	Model 1	Model 2
<i>Segmented Immobility</i>		
Political dissimilarity	-0.368***	-0.256***
Rural dissimilarity		-0.399***
Racial dissimilarity	-0.361***	-0.217***
<i>Control Covariates</i>	(included)	

Note: *** $p < 0.001$ (two-tailed tests)

Future Projects

Future Projects

- International migration systems
 - Evolution of global visa-waiver network
 - with Jacob Thomas (CUHK)
 - socio-cultural affinity; security: terrorism and global pandemic; international relations
 - Evolution of international migration flows
 - with Jeffrey Johnson (UoF)
 - political violence, and climate change
 - short-term & long-term impacts via simulation
 - longitudinal valued network models

Future Projects

- Spatial network and neighborhood effects
 - with John Hipp (UCI), Carter Butts (UCI), Zack Almquist (UW), and Loring Thomas (Princeton)
 - spatial distribution of social contact in urban areas
 - health risks and exposure to crime
 - varying social connection patterns by race, ethnicity, and sex

Future Projects

Migrant Social Networks

- Diffusion of migration opportunities
 - Migrant-sending areas in Southeastern China
 - Archival data on transportation network, economic structures, and lineage networks
- Immigrant integration
 - change of social networks over time and generation

Future Projects

- Methodology and mathematical sociology
 - temporal models for valued network analysis
 - stochastic process of valued network models
 - network regression (MR-QAP) for discrete data
 - Simulation models for immobility and segregation (empirically calibrated)

Methods

Valued ERGMs

- ERGMs: parametric statistical model on network structure (Wasserman & Pattison 1996).

$$\Pr(Y=y) = \frac{h(y)\exp(\theta^T t(x, y))}{k(\theta)}$$

$$k(\theta) = \sum_{y' \in \mathcal{Y}} h(y')\exp(\theta^T t(x, y'))$$

- Valued: edges are not binary, but counts, using different reference measure (Krivitsky 2012).

e.g. $h(y) = 1 / \prod_{(i,j) \in \mathbb{Y}} y_{i,j}!$, $y_{i,j} \sim \text{generalized Poisson dist.}$

MPLE

- Maximum Pseudo Likelihood Estimation
 - GLM for each dyad (Besag 1974; Strauss & Ikeda 1990)
 - $\Pr(Y = y) \approx \prod_{(i,j) \in \mathbb{Y}} \Pr(Y_{ij} = y_{ij} | Y_{ij}^c)$
 - $\Pr(Y_{ij} = y_{ij} | Y_{ij}^c) = \frac{h(y_{ij}, Y_{ij}^c) \exp(\theta^T t(y_{ij}, Y_{ij}^c))}{\sum_{k=0}^{\infty} h(k, Y_{ij}^c) \exp(\theta^T t(k, Y_{ij}^c))}$
 - Parallel computing and subsampling
 - Implemented and tested in Huang & Butts 2024
 - Accurate estimation and high-speed for high-variance valued networks

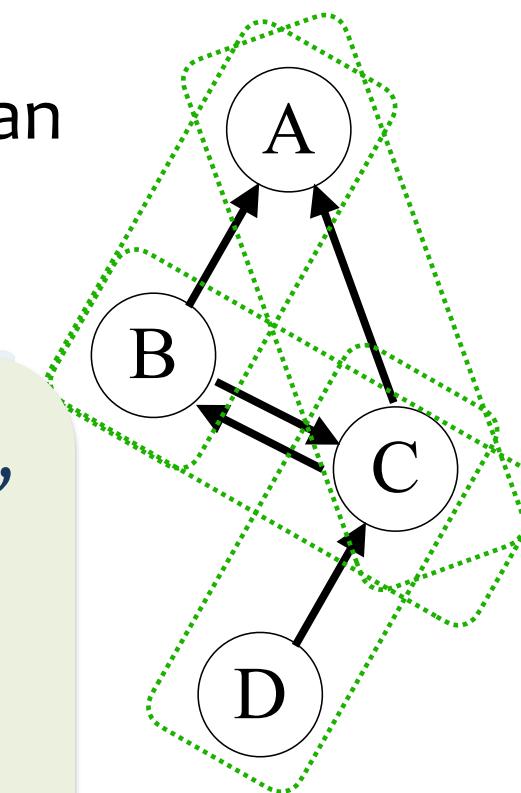
Internal Dynamics

Migration Systems Theory

Migration Systems

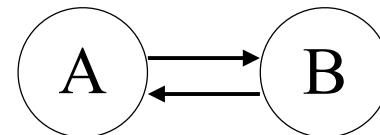
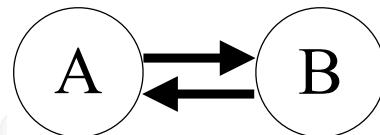
- The interdependence of migration flows
 - e.g., Reciprocity
- Migration flows between places form an interconnected system (MST)
- Not only a remedy of autocorrelation.

“a circular, interdependent, progressively, complex, and self-modifying system in which the effect of changes in one part can be traced through the whole of the system” (Mabogunje 1970:16)



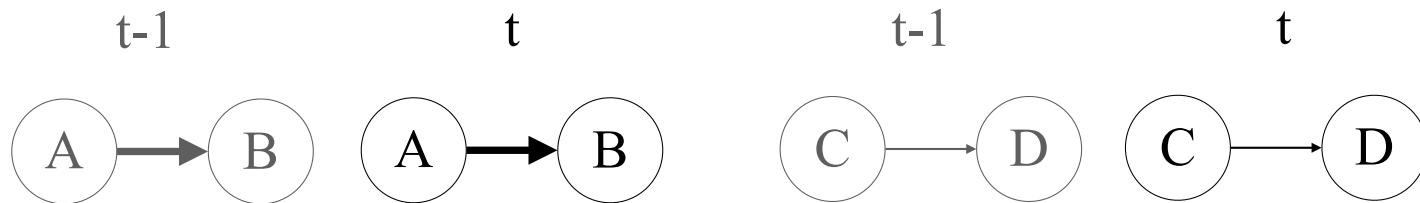
Internal dynamics: reciprocity

- Interdependence of migration flows
- Transnationalism: migration is an enduring reciprocal exchange of people, goods, and cultures between sending and receiving countries (Schiller, Basch, and Blanc 1995; Waldinger 2013)
- Internal Migration: “Counter-currents of migration” (Ravenstein 1885: 187)
- H4: *Ceteris paribus, migration flow from county A to county B increases with the migration flow from B to A*



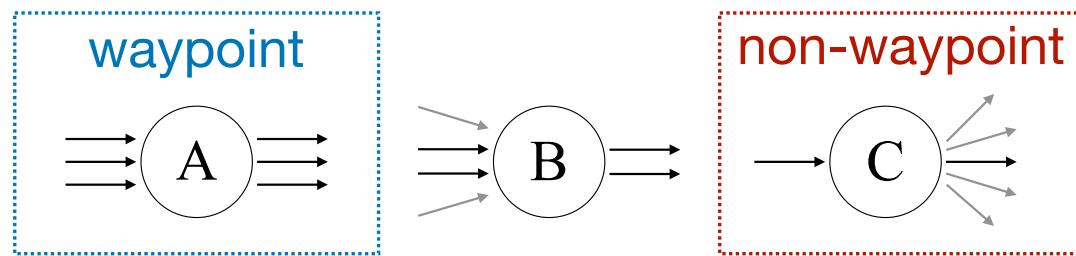
Internal dynamics: perpetuation

- Cumulative causation: migration alters the social contexts in ways that make future migration more likely (Massey 1990; Massey et al. 1993)
 - migrant networks, information, resources, and institutional changes
- *H5: Ceteris paribus, the flow of migration from county A to B increases with the past flow of migration from county A to county B.*



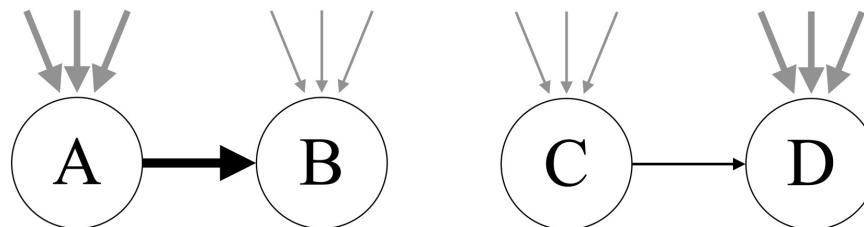
Internal dynamics: waypoint flow

- Waypoint: balanced immigration and emigration flow, like a transfer station
- Result from chain-like migration (Leal 2021)
 - stepwise migration: multi-stops migration process
 - relay migration: immigration drive emigration or the reverse
- H6: *Ceteris paribus, the inflows of migration to a county increase with its outflows.*



Internal & international migration

- Demographic balkanization (Frey 1995): immigrant inflows 1) trigger outflows and 2) deter inflows
 - Conflicting empirical findings (Borjas 2006; Card 2001; White & Liang 1998; Wright, Ellis & Reibel 1997)
- *H7: Ceteris paribus, an internal migration flow increases with international immigration inflow in the sending county, but decreases with international immigration inflow in the receiving county..*



Data and Variables

- Internal dynamics

- Reciprocity

$$g_m(y) = \sum_{(i,j) \in \mathbb{Y}} \min(y_{ij}, y_{ji})$$

- Perpetuation

- past migration flow in 2006-10 (in log)

- Waypoint flow

$$g_f = \sum_{i \in \mathbb{V}} \min\left\{\sum_{j \in \mathbb{V}, j \neq i} y_{ij}, \sum_{k \in \mathbb{V}, k \neq i} y_{ki}\right\}$$

Conclusion

- A relational approach to study inter-county migration flow system using network methods
- Internal dynamics of migration: reflected by interdependence of migration flows, such as reciprocity, suppression of waypoint
- lend empirical evidence to the systemic theory of migration: an interdependent network system that carries its own momentum

Discussion

- Segmented immobility (SI) suggests a limited population exchange between communities with different cultural, political, and racial environments
- Not only a mechanism of immobility
- It opens the door for the inquiry about the relationship between **immobility, segregation, and polarization**
- Migration process has always been at the core of segregation model (Fossett 2006; Sakoda 1971; Schelling 1969), but more needs to be done

Discussion

Segregation

Immobility

Polarization

Clarifications

Economists' puzzle

- Demographic and labor market structures has little explanatory power to the low mobility rate
- “[demographic and employment type] composition and the returns to migration have limited ability to explain recent changes in interstate migration” (Hyatt et al. 2018)
- “We find little support for several explanations, including the rise of dual-career households, the decline in middle-skill jobs, occupational licensing, and the need for employees to retain health insurance.” (Molloy et al. 2017)

Segmented Immobility

- Rural-urban division
 - economic reasons: specialized human capital
 - cultural reasons: lifestyle
- Racial Segregation
 - economic reasons: ethnic capital (Fernandez-Kelly 2008; Lee and Zhou 2017)
 - cultural reasons: cuisine, religious practice, etc.



Immobility

An Inquiry of Immobility

- What **inhibits** migration?
 - The state (Waldinger & Fitzgerald 2004)
 - International migration: passport-visa-border control-enforcement & removal
 - The nature of immigration politics & policies is restriction (Lahav & Messina 2023)
- Once we enter a country without state control over domestic migration (e.g., USA), we should enjoy a lot of mobility, right?

Immobility is not the flip side of mobility

- We have studied extensively about what empowers people to migrate (financial, social, political capital etc.)
 - This framework can make us assume that immobility is a failure to migrate (without those empowerment)
- BUT both mobility and immobility can be voluntary choices, reflecting different cultures
 - “culture of migration” & “culture of staying” (Stockdale & Haartsen 2018)

Immobility is not the flip side of mobility

- In the marginal analysis, in-migration and out-migration are not distinguishable
 - neither are mobility and immobility
 - high net in-migration rate can be due to large in-flow (mobility) or small out-flow (immobility), or both
- The relational analysis directly focuses on the magnitude of migration flow
 - the variation of interest is mobility vs immobility

Immobility is not the flip side of mobility

- Different focuses inspires us to ask different questions
- e.g., “voting with your feet”
- Mobility: variation among migration
 - blue->red vs. red->blue? what policy/climate attracts more migrants
- Immobility: variation between migration and non-migration
 - what stops people from making a move? an environment they do not identify with?

Discussion

“While internal migration in the U.S. does not involve border-crossing for international migration or other forms of governmental restrictions, population movement is never free of constraints.”

“Rather, Americans today are separated by the invisible borders and walls standing along the party lines, at the midway between rural and urban landscapes, and over the gap across communities with varying racial demographics.”

Appendix

**Descriptive statistics
Adequacy check**

Table A1. Descriptive Statistics of Inter-county Migration Flow Networks

	2011-2015	2006-2010
Vertices	3,142	3,142
Edges	274,197	241,526
Density	0.028	0.024
Mean degree ¹	175	154
Total migrant	17,176,675	17,248,855
Mean migrants per county ²	10,934	10,980
Mean migrants per flow	63	71

1. The reported degree is the total degree (Freeman degree), which equals the summation of in and out degree (Freeman 1978). For a closed network system, the mean in-degree equals to the mean out-degree.
2. Similarly, the mean migrant per county is the summation of mean in-migrants and mean out-migrants per county (and mean in-migrants equals to mean out-migrants).

Table A2. Descriptive Statistics of Vertex/County Covariates

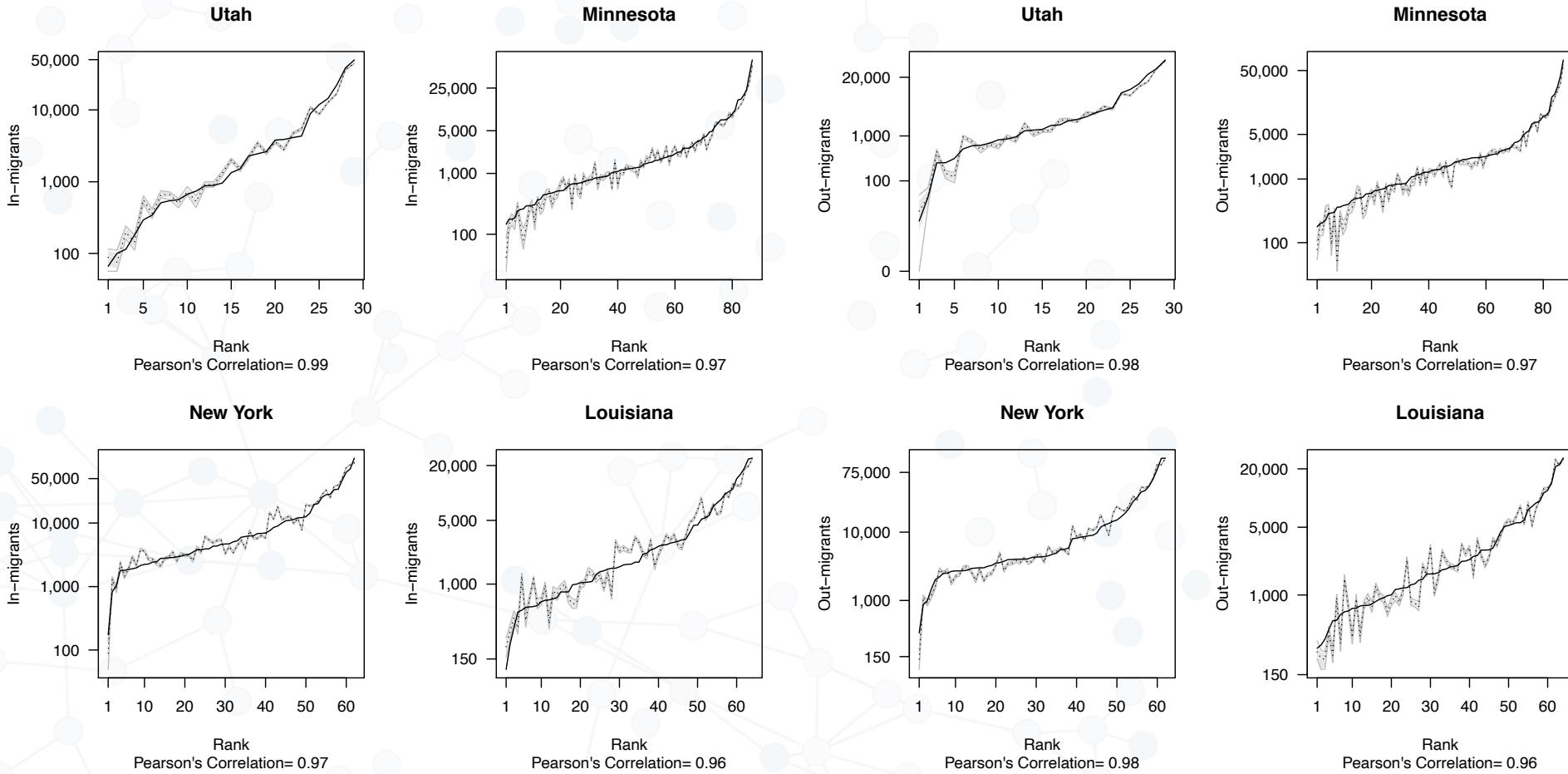
	Mean	Str Dev	Source
<i>Networks</i>			
Immigrant inflow	593.9	2744.3	ACS2011-2015
<i>Politics</i>			
Democrat poll (%)	41.6	13.9	Presidential Election Returns 2008
<i>Demographics</i>			
Population size	98,262.0	312,946.7	Census2010
Population density (/km ²)	100.0	665.8	Census2010
Potential Support Ratio (PSR)	4.4	1.5	Census2010
Higher education (%)	19.0	8.7	ACS2006-2010
White (%)	78.3	19.9	Census2010
Black (%)	8.7	14.4	Census2010
Hispanic (%)	8.3	13.2	Census2010
Asian (%)	1.1	2.5	Census2010
Other race (%)	3.5	8.3	Census2010
<i>Economics</i>			
Renter (%)	27.8	7.7	Census2010
Unemployment (%)	7.5	3.4	ACS2006-2010
<i>Geographics</i>			
Rural population (%)	58.7	31.5	Census 2010
Northeast (%)	6.8		U.S. Census Bureau
South (%)	45.3		U.S. Census Bureau
West (%)	14.3		U.S. Census Bureau
Midwest (%)	33.6		U.S. Census Bureau

Table A3. Descriptive Statistics of Dyadic/County-Pair Covariates

	Mean	Str Dev	Source
<i>Dissimilarity</i>			
Political dissimilarity (%)	15.6	11.8	Presidential Election Returns 2008
Rural dissimilarity (%)	36.1	26.1	Census2010
Racial dissimilarity (%)	24.8	20.0	Census2010
<i>Difference</i>			
Unemployment (%)	0 ¹	4.7	ACS2006-2010
<i>Geographics</i>			
Distance (km)	1,439.5	961.3	Census2010

Note: 1. The mean of the dyadic difference measure for a closed system by design should be zero.

Adequacy check



California Exodus

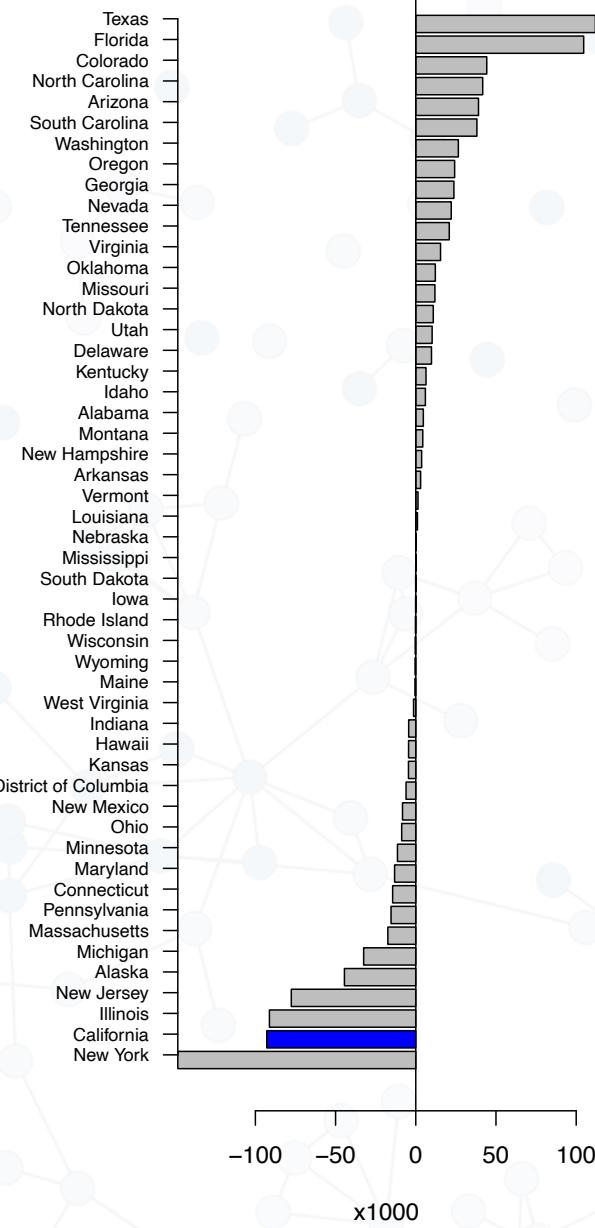
Population Redistribution

U.S. Population System

	Count	Crude rate (%)
Population	308,739,316	
<i>Natural Change</i>		
Births	3,961,037	1.28
Deaths	2,598,956	0.84
Natural Increase	1,362,081	0.44
<i>International Migration</i>		
Immigration	1,841,695	0.60
<i>Inter-county Migration</i> $Y_{(i,j)}$		
Total migrants ($\frac{\sum_i \sum_j Y_{ij}}{2}$)	17,176,675	5.56
Node-level asymmetry ($\frac{\sum_i Y_{i\cdot} - Y_{\cdot i} }{2}$)	1,523,550	0.49
Edge-level asymmetry ($\frac{\sum_j \sum_i Y_{ij} - Y_{ji} }{2}$)	3,844,434	1.25

Note: Population size from 2010 Census; 2011-2015 mean annual count of changes (natural change: CDC, migration: ACS)

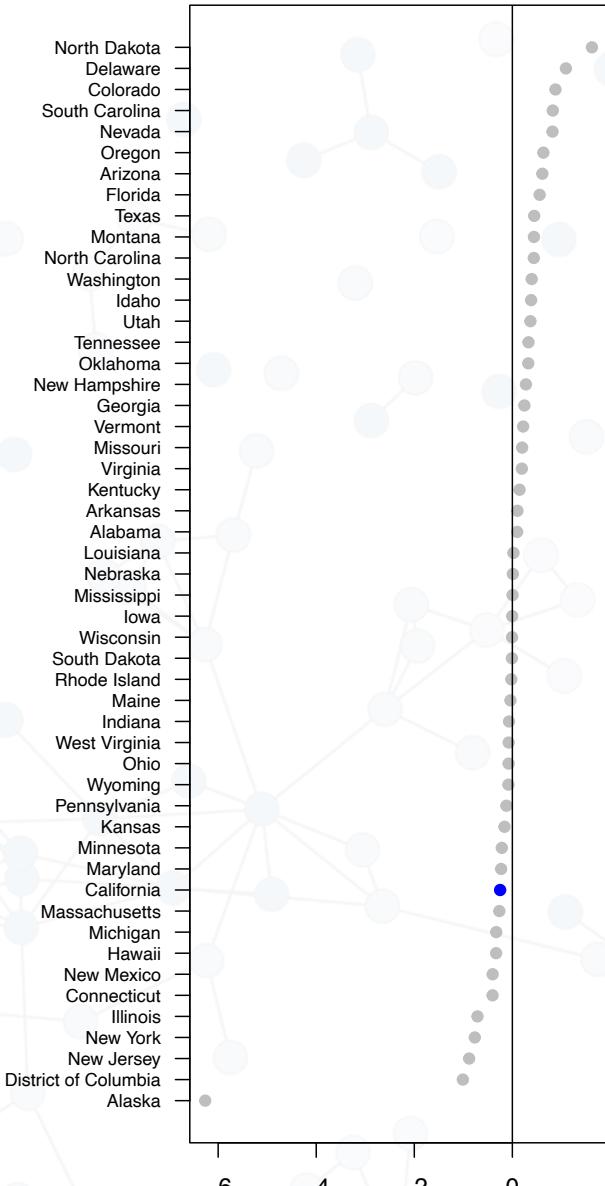
Net Migrant Count



Net Migrant Count

- $Y_{\cdot i} - Y_i$.
- California has large migrant population loss

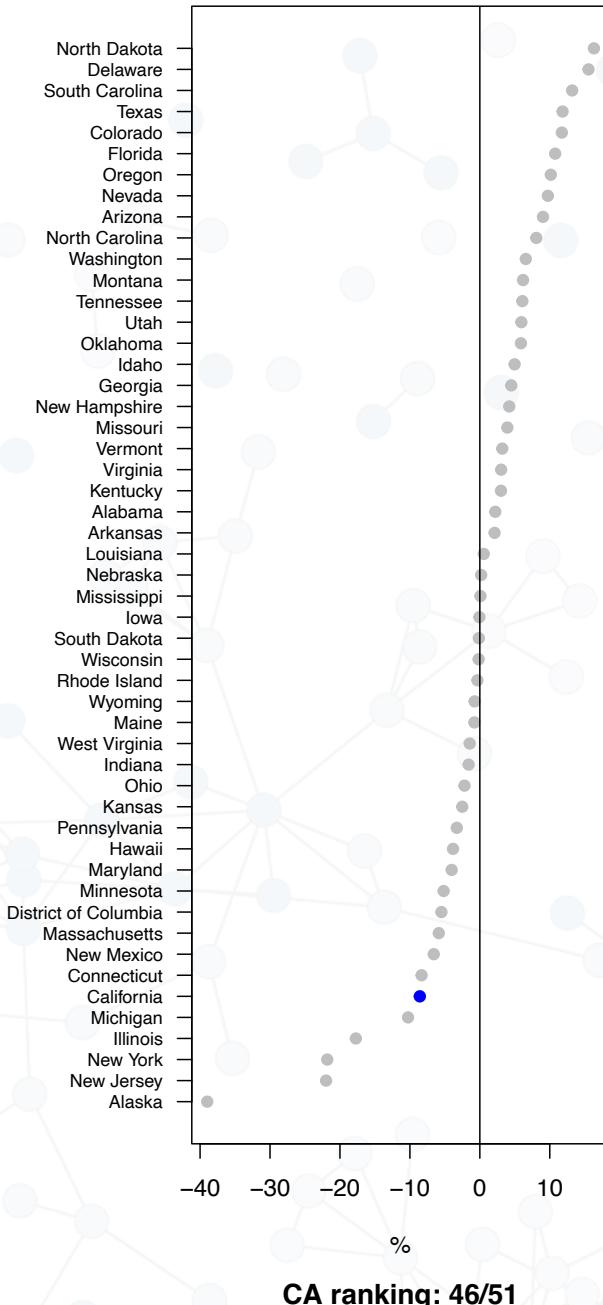
Net Migration Rate



Net Migration Rate

- $(Y_{\cdot i} - Y_{i \cdot})/P_i$
- Not very different from the majority of states after controlling for population

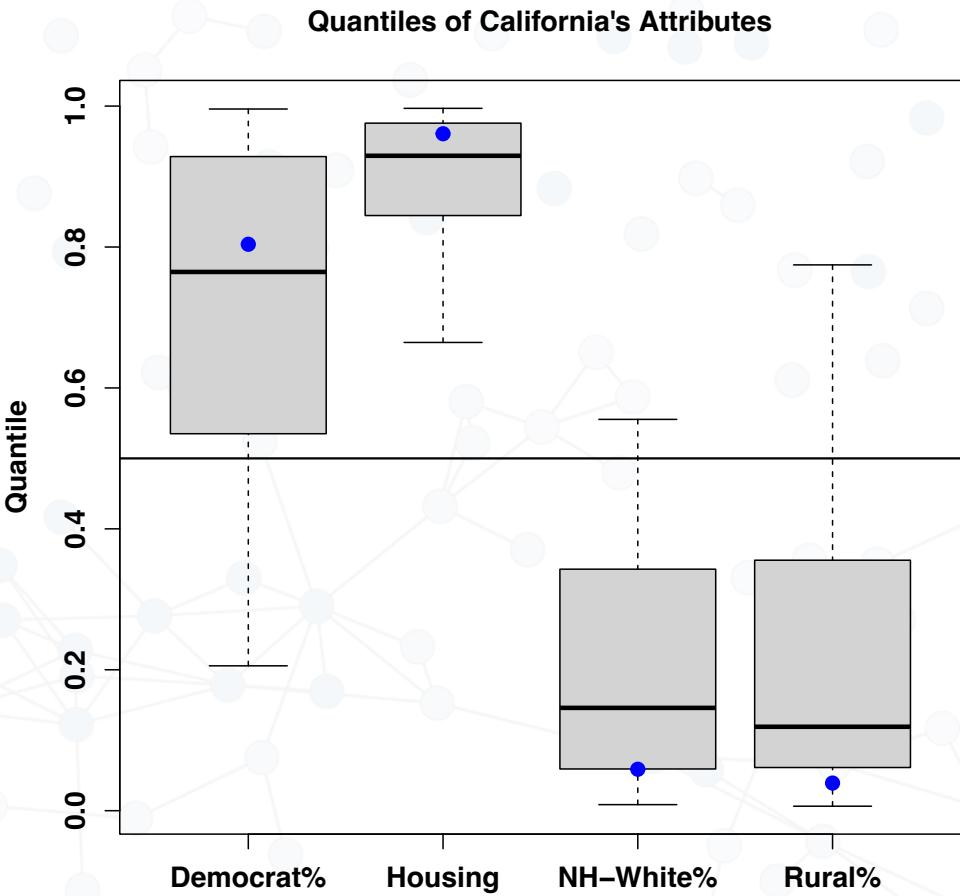
Migration Imbalance Index



Migration Imbalance Index

- $(Y_{\cdot i} - Y_{i \cdot}) / (Y_{\cdot i} + Y_{i \cdot})$
 - External-Internal (E-I) Index
(Krackhardt & Stern 1988)
- Larger variation in imbalance of in-&out- flows
- California is among the lower ends

Possible Drivers of Exodus



Compared to other U.S. states, California has more

- Democratic-party voters
- expensive housing
- minority population
- urban population