Centrality Measures of Internal Migration

Graph Theory Independent Study

Mary Anna Kivenson
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Introduction

Data

- Annual Internal county net migration from 2011 to 2015
- Internal state net migration in 2012
- Economic, Voting, Housing, and Demographic data by location

Migration Graph

- **Graph**: Weighted digraph
- **Nodes**: Represent a county or state
- **Edges**: Net migration movement and direction
- **Weight**: Quantity of migrants between locations

Degree Centrality: Quantity of locations migrants are coming from and leaving to.

Weighted Degree Centrality: Calculated as the sum of migrants flowing to the direct connections of a node.

Closeness Centrality: Calculated based how many different places each county is linked to. In other words, it is the "popularity" of a location.

Eigenvector Centrality: A location has high centrality if connected to linked locations.
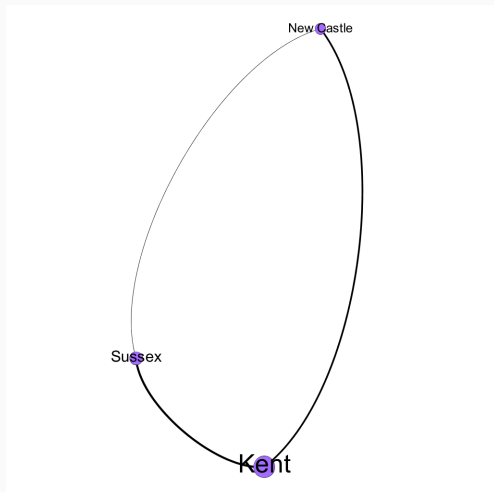
Sample Migration Graph

Figure 1: Sample Weighted Graph: Delaware County-to County Migration, 2011-2015
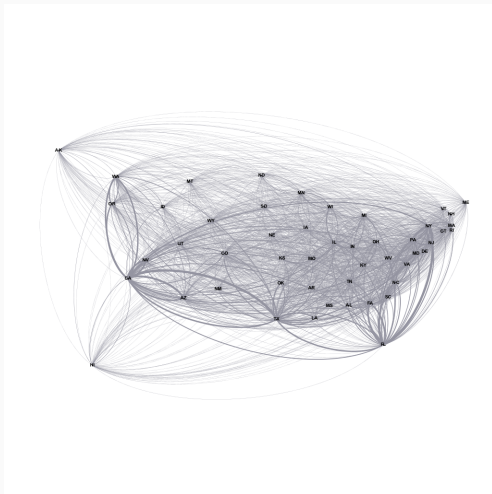
State Migration Graphs

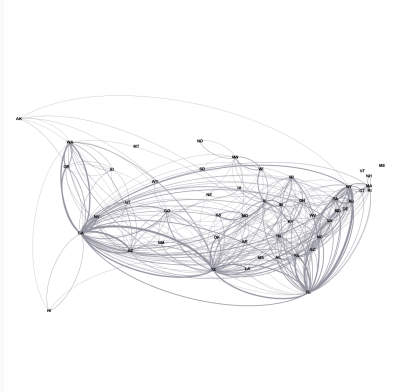**Figure 2:** Annual State migration, 2012. All edge weights included

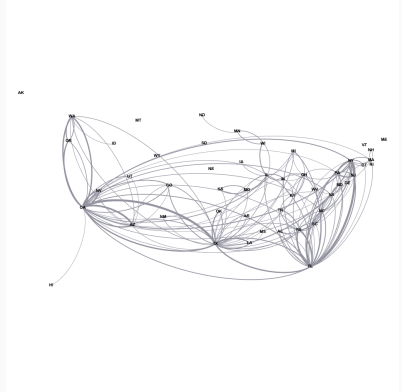Figure 3: Annual State migration, 2012. Edge weights of 5000 and above.

Figure 4: Annual State migration, 2012. Edge weights of 10000 and above.
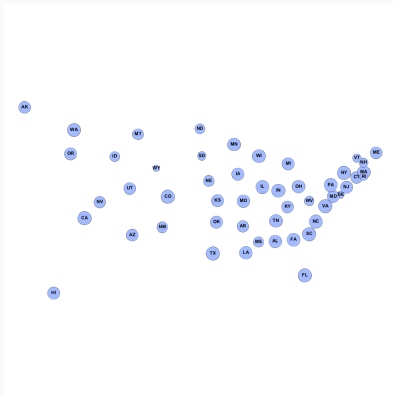
State Degree Centrality
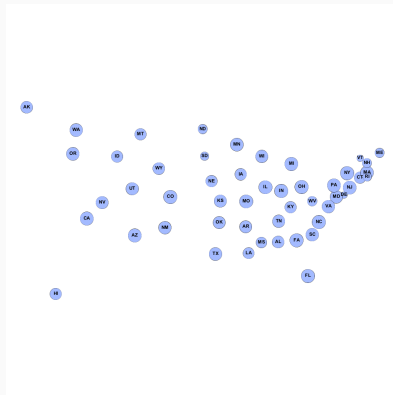

Figure 5: Migration in-degree by state, U.S. 2012

Figure 6: Migration out-degree by state, U.S. 2012

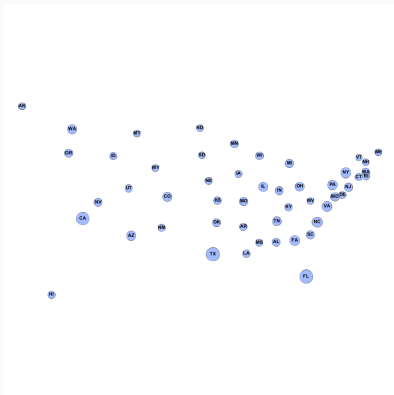# State Weighted Degree Centrality

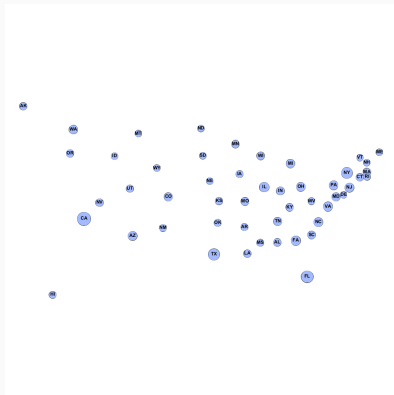Figure 7: Migration weighted in-degree by state, U.S. 2012

Figure 8: Migration weighted out-degree by state, U.S. 2012

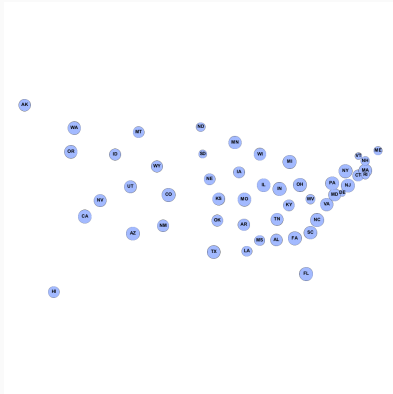# State Closeness and Eigenvector Centrality

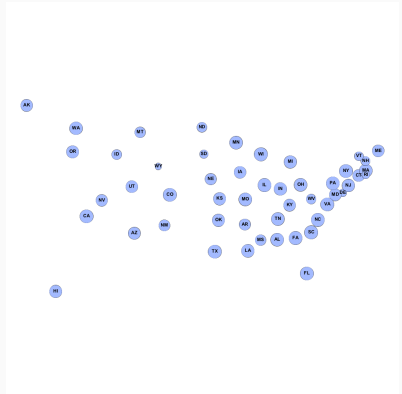Figure 9: Closeness centrality measure of states based on migration, U.S. 2012

Figure 10: Eigenvector centrality measure of states based on migration, U.S. 2012

Population Normalization

Normalized In-Degree

State	Norm. In-Deg: Top 10	State	Norm. In-Deg: Bottom 10
FL	0.0493790297110834	WI	0.0190078651318509
AK	0.047621115955327	MN	0.0185130652812363
ND	0.0439618543791465	PA	0.0183222937859231
HI	0.0405350668269979	IL	0.0167852689863345
WY	0.0403575775524563	OH	0.0165409094214045
NV	0.0388662036794067	NJ	0.0156848573674156
CO	0.0377388082524843	NY	0.0142917935664368
ID	0.0369148540438945	MI	0.014042353906108
DE	0.0362457167165092	GA	0.0136265496865603
AZ	0.0331096382313321	CA	0.0120721087558791

Normalized Out-Degree

State	Norm. Out-Deg.: Top 10	State	Norm. Out-Deg.: Bottom 10
AK	0.120600163967359	NY	0.0191327690094923
WY	0.0547647619716068	MN	0.0189206022971967
HI	0.0436332077311225	MI	0.0188201124998827
FL	0.0432987172962234	LA	0.0186234481714425
NV	0.040837955985332	WI	0.0182719636290626
ND	0.0359210907094426	OH	0.0177717874071634
ID	0.0353822415177086	PA	0.0168236086545547
SD	0.0332171008292554	TX	0.0149661174677054
NH	0.0326172565387888	CA	0.0144924424972618
KS	0.0324308949556494	GA	0.0125113499285714

County Migration Graphs
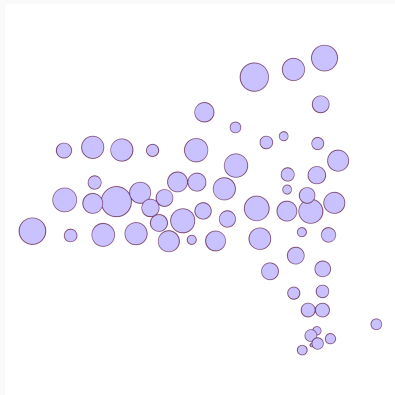
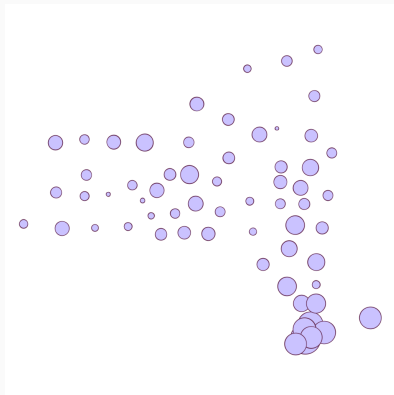**Figure 11:** Migration in-degree by county, NYS 2011-2015

Figure 12: Migration out-degree by county, NYS 2011-2015.
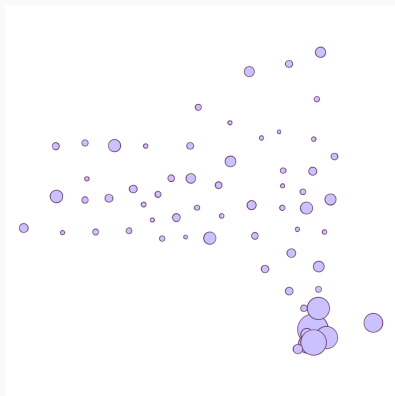
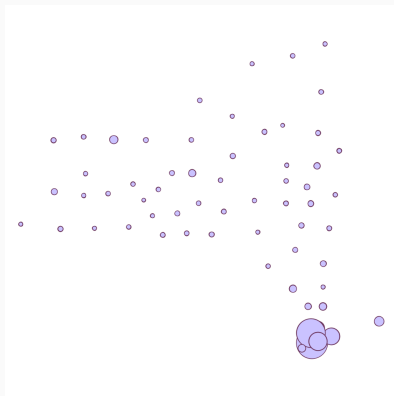Figure 13: Migration weighted in-degree by county, NYS 2011-2015

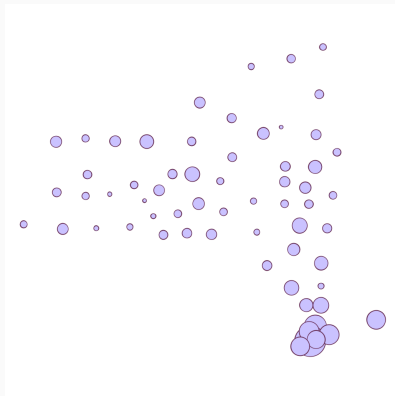Figure 14: Migration weighted out-degree by county, NYS 2011-2015

Figure 15: Closeness centrality of counties based on migration flow, NYS 2011-2015
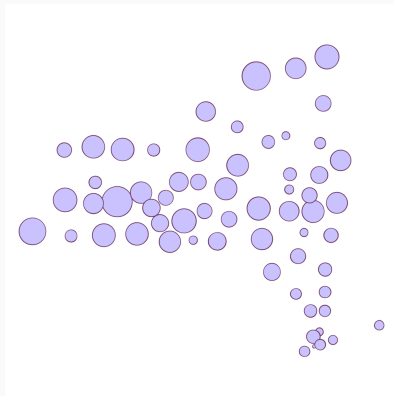
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Centrality Measure Correlations
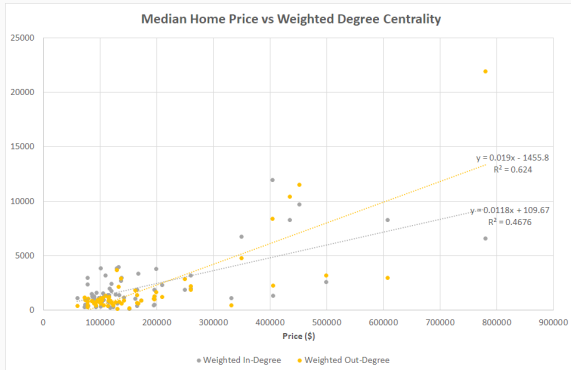
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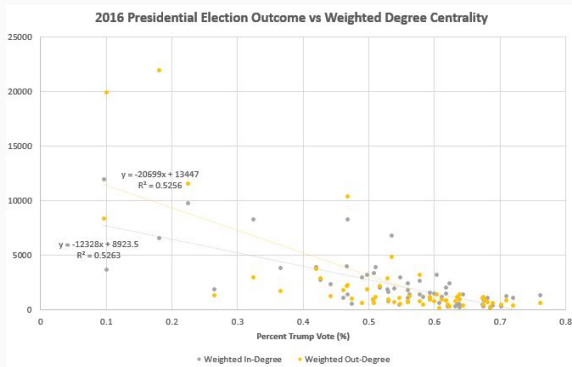
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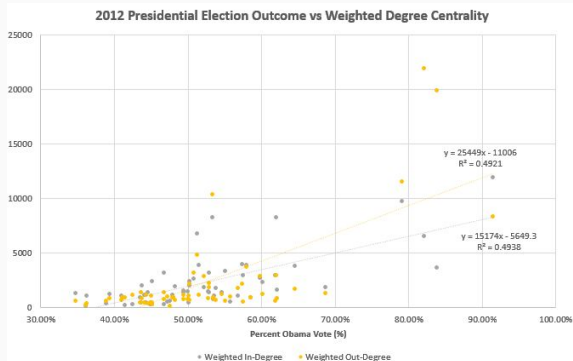
Figure 19: 2012 Presidential Election Outcome vs Weighted Degree

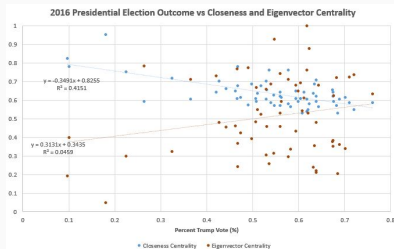Figure 20: 2016 Presidential Election Votes vs Closeness/Eigencentrality
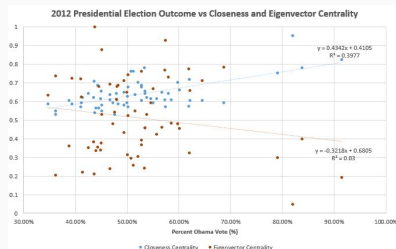
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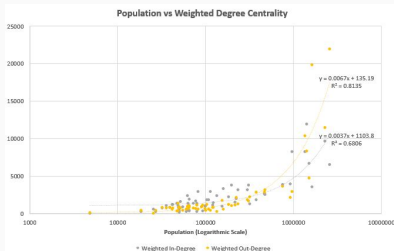
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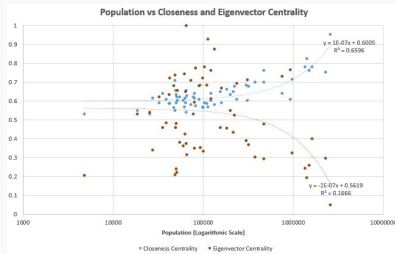
Figure 23: Population vs Closeness/Eigencentrality
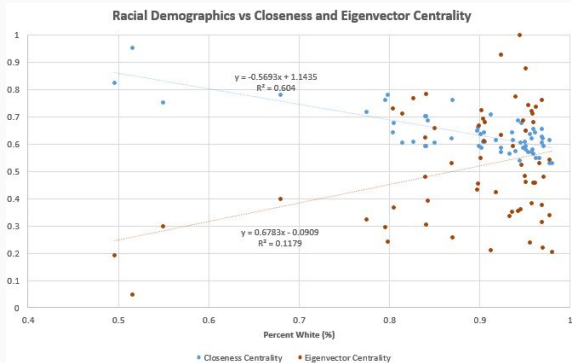
Figure 24: Racial Demographics vs Weighted Degree

Figure 25: Racial Demographics vs Closeness/Eigencentrality

[Kin17] S. Kingan. "Graph Theory and Applications". preprint. Aug. 2017.

[Uni12] United States Census Bureau. State-to-State Migration for States of 8 Million or More.
https://www.census.gov/dataviz/visualizations/028/508.php. Dec. 2012.

[Uni15] United States Census Bureau. County-to-County Migration Flows: 2011-2015 ACS.
https://www.census.gov/data/tables/2015/demo/geographicmobility/count-to-county-migration-2011-2015.html.
2011-2015.

[Wor11] World Bank. Internal mobility: The United States. 2011.