Global Migration Flows, 1960-2000: Mapping Out the International Migration Network.

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THE ISSUE

Migration is a fundamental and ubiquitous sociodemographic force inherent to human societies. In the last few decades, there has been a call to study international migration from a complex-network perspective (Fagiolo and Mastrorillo 2013).

In this context, this research project is designed to be a descriptive and inferential network-based analysis of the global migration flows. In this study I analyze a total 185 countries during the last four decades of the twentieth century.

My concrete object of study is the international migration network and its gendered-versions: the women's international migration network and the men's international migration network.

DATA AND ANALYSIS

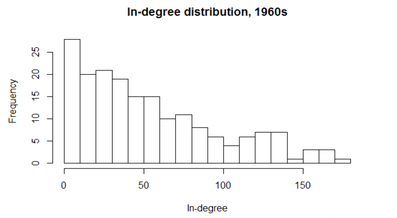
I generated data on migration flows between 185 countries spanning the period 1960-2000. The flows are primarily based on the *Global Bilateral Migrant Stock Database* (Özden et al. 2011). The migration flow data were estimated using the *migration flows from stocks* (ffs) methodology (Abel 2010, 2013, 2014) implemented in the *migest* R package (Abel 2012).

I rely on two R packages to describe the network data: *statnet* (Handcock et al. 2008) and *igraph* (Csardi and Tamas 2006). I model cross-temporal dynamics by fitting TERGMs via bootstrapped pseudolikelihood using the *xergm* R package (Leifeld 2015 et al.).

NETWORK DESCRIPTIVE STATISTICS

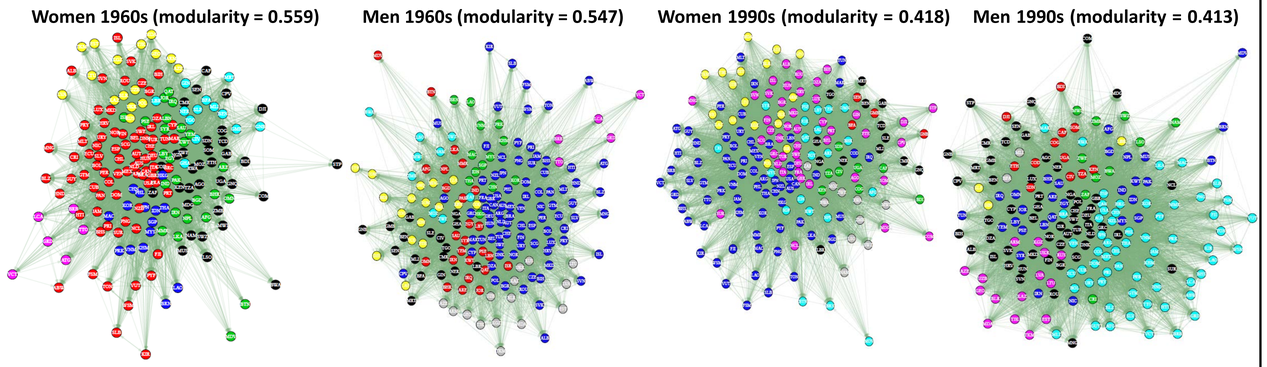
1960s	Men and Women		Women		Men	
	All Flows	Flow > 10	All Flows	Flow > 10	All Flows	Flow > 10
Density	0.416	0.222	0.356	0.178	0.370	0.186
Centralization	0.437	0.564	0.506	0.581	0.483	0.576
Mean in-degree	76.454	40.795	65.459	32.708	68.168	34.162
Number of nodes	185	185	185	185	185	185
Number of edges	14144	7547	12110	6051	12611	6320
Dyad census						
Mutual	3635	1685	3004	1277	3072	1301
Asymmetric	6874	4177	6102	3497	6467	3718
Null	6511	11158	7914	12246	7481	12001

1990s	Men and Women		Women		Men	
	All Flows	Flow > 10	All Flows	Flow > 10	All Flows	Flow > 10
Density	0.518	0.296	0.455	0.242	0.472	0.253
Centralization	0.400	0.566	0.447	0.596	0.438	0.588
Mean in-degree	95.265	54.449	83.649	44.491	86.816	46.524
Number of nodes	185	185	185	185	185	185
Number of edges	17624	10073	15475	8231	16061	8607
Dyad census						
Mutual	5301	2545	4369	1944	4698	2086
Asymmetric	7022	4983	6737	4343	6665	4435
Null	4697	9492	5914	10733	5657	10499



Sources: Network data on migration flows are estimated using the flows from stocks methodology (Abel 2010, 2013, 2014). Country-level data on population size, fertility, and mortality rates were downloaded from the UN population division website. Stock data were obtained from the World Bank Global Bilateral Migrant Stock Database (Özden et al. 2011). *Data on bilateral distances between countries were obtained from CEPII (Mayer and Zignano (2011)*

COMMUNITY DETECTION USING THE WALKTRAP ALGORITHM



Note: All the networks are plotted using the Fruchterman-Reingold algorithm.

TEMPORAL EXPONENTIAL-FAMILY RANDOM GRAPH MODEL (MEN & WOMEN)

TERGM Results

Degeneracy Check (high p-vals are desirable)

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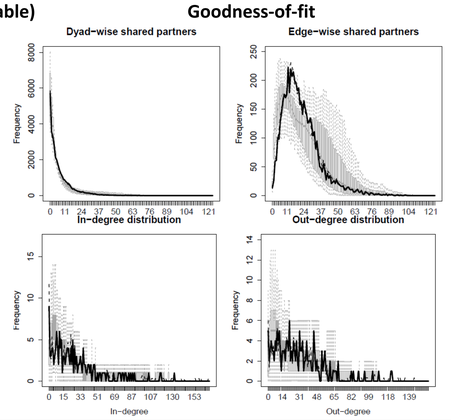
Degeneracy check for network 1:
                                  obs   sim   est    se  zval pval
edges                            5117  6076   959  1740  0.55 0.58
mutual                           1003  1292   289   434  0.67 0.51
ttriple                         91988 151739 59751 98393  0.61 0.54
transitiveties                   5103  6055   952  1747  0.55 0.58
ctriple                         17592 28988 11396 17255  0.66 0.51
nodeicov.idegsqrt               35877 45985 10108 15560  0.65 0.52
nodeicov.odegsqrt               29262 37807  8005 13254  0.60 0.55
nodeocov.odegsqrt               34113 42225  8112 12473  0.65 0.52
nodematch.region                 1393  1410   103   292  0.36 0.72
edgecov.delrecip[[1]]            2136  2497   362   631  0.57 0.57
edgecov.mem.stability[[1]]       1141   870  -271   399 -0.68 0.50

Degeneracy check for network 2:
                                  obs   sim    est     se  zval pval
edges                            6020  6076   56.34 1740.39  0.03 0.97
mutual                           1325  1292  -33.74  433.58 -0.08 0.93
ttriple                        131342 151739 20396.66 98392.82  0.21 0.84
transitiveties                   6006  6055   49.41 1747.39  0.03 0.98
ctriple                         27344 28988 1644.48 17254.91  0.10 0.92
nodeicov.idegsqrt               44586 45985 1398.25 15559.49  0.09 0.93
nodeicov.odegsqrt               37656 37807   151.41 13253.98  0.06 0.95
nodeocov.odegsqrt               42094 42225   131.24 12473.04  0.01 0.99
nodematch.region                 1575  1410  -165.17   291.54 -0.57 0.57
edgecov.delrecip[[2]]            2495  2497     1.49   631.13  0.00 1.00
edgecov.mem.stability[[2]]        940   870   -70.45   398.77 -0.18 0.85

Degeneracy check for network 3:
                                  obs   sim    est     se  zval pval
edges                            6680  6076  -603.7  1740.4 -0.35 0.73
mutual                           1507  1292  -214.7   434.0 -0.49 0.62
ttriple                        174440 151739 -22707.3 98392.8 -0.23 0.82
transitiveties                   6672  6055  -616.6  1747.4 -0.35 0.72
ctriple                         37450 28988 -8461.5 17254.9 -0.49 0.62
nodeicov.idegsqrt               54214 45985 -8228.8 13559.5 -0.61 0.54
nodeicov.odegsqrt               44861 37867 -6993.9 13254.0 -0.53 0.60
nodeocov.odegsqrt               47694 42225 -5468.7 12473.0 -0.44 0.66
nodematch.region                 1432  1410   -22.2   291.5 -0.08 0.94
edgecov.delrecip[[3]]            2986  2497  -488.5   631.1 -0.77 0.44
edgecov.mem.stability[[3]]        964   870   -94.4   398.8 -0.24 0.81
```

Goodness-of-fit



Note: 5000 bootstrapping replications are used for estimation. Goodness-of-fit and degeneracy checks are based on 200 simulations.

CURRENT CHALLENGES

Incorporate weighted ties in the inferential analysis. As of now, the results are based on binary networks.

Incorporate key exogenous covariates: country size, GDP per capita, common official language, and common religion.

Incorporate exogenous covariates that may help to tease out differences between men's and women's migration flows.

- A key concept in this context is related to the idea of "care deficit." A likely candidate to model care deficit is the proxy variable *potential for support,* defined as difference between the ratio of the population between 15 and 64 years old per population 65 years old or older.

Devise a clear and simple way to qualitatively compare differences between women's and men's networks. A possible way to this is to analyze changes over time in the community structure of these networks.

Improve the fit of the TERGM. Currently some of results captured in the box plots based on the TERGM, especially the one related to edge-wise shared partners, can be enhanced.

Include some of the currently missing countries by gathering data about them. A special case deserves attention: Taiwan.

Run more simulations for the degeneracy check.

FURTHER RESEARCH

It would be very interesting to compare the results from the TERGMs estimated in this research project to results from comparable models developed under the stochastic actor-based model approach (Snijders et al. 2010).

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