4_Network+Effects+I

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Advanced Network Analysis
4. Network Effects I: Relational Effects

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Network Effects

Network formation → network effects

In the last section, we treat networks as the dependent variable. In this section, we study networks as a predictor.

- Relational effects from network ties
- Positional effects from network positions
- Structural effects from network structure

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Relational Effects

The literature on relational effects can be divided into two groups.

- The social capital literature shows how social networks provide access to social resources and social support.
  - Economic Sociology: Career advancement (Granovetter 1973; Fernandez and Weinberg 1997; Lin 1999; Bian 1997; Mouw 2003; Podolny and Baron 1997; Dowd and Pinheiro 2013)
  - Medical Sociology: Social support (Pescosolido 1991; Song 2011; Thoits 2011; Perry and Pescosolido 2015; Small 2013, 2017; Small, Mario L. 2013; Small and Sukhu 2016)
- The social contagion model shows social norms and behaviors can transmit through social networks (Christakis and Fowler 2008; Friedkin 2006; Friedkin and Johnsen 1990, 2011; Marsden and Friedkin 1993).

The Social Capital Model

$$Y_i = \beta_0 + \beta_1 \text{Social Capital}_i + \beta_2 X_i + \epsilon_i$$

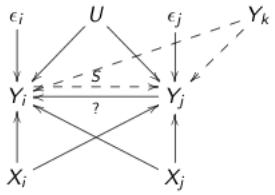
- Measurement
  - Existence of ties
  - Number of ties
  - Strength of ties
  - Diversity of ties (Uzzi 1999)
- Selection issues: People with more relational capital may differ from those with less relational capital.
  - Selected based on observables. Use matching or propensity score methods to address the issue.
  - Selected based on unobservables. Need exogenous information from instrumental variables or experiments.
- Teasing out the mechanisms (from affiliation to status)
  - Information (Granovetter 1973)
  - Influence (Lin 1999; Bian 1997, 2010)
  - Inference: from affiliation to status (Podolny 1993)
- Cultural, institutional, and temporal variations
  - some people use binary ties but not enough etc. depends on strength of tie, how many ties, etc. → think iPhone users

vary across time, cultures, etc.

- Measuring group vs. individual level
  - group level has less variation bc fewer data points, big Std errors

① control observed competing covariates like education, income, etc.

The Social Contagion Model



$$Y_i = \beta_1 Y_j + \beta_2 X_i + \beta_3 X_j + \epsilon_i \quad (1)$$
$$Y_j = \alpha_1 Y_i + \alpha_2 X_j + \alpha_3 X_i + \epsilon_j \quad (2)$$

Potential causal inference threats to peer influence:

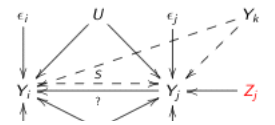
- Peer selection → you selected friend before they exhibited smoking behavior — selection inference
- Contextual confounding → live in geography that cigarettes are more prevalent/ policy against
- Simultaneity → friend influences you, but you also influence them
- Measurement error → Y = smoking, appears on both sides of equation → Consequence: Std error will be larger/inflated

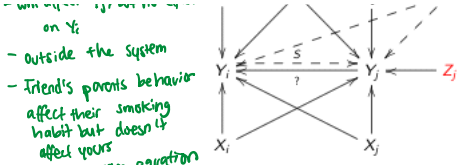
$\beta_1 = \frac{\text{coef (v)}}{SE(\hat{})}$ so t-value goes down, p-value goes up

Absolute size of error will shrink estimate towards 0 less likely to reject $\beta_1 = 0$ / find significant β_2

Solution I: Instrumental Variables

Find additional var Z_j
- will affect Y_j, but no effect on Y_i
- outside the system
- friend's parents behavior





$$Y_i = \beta_1 Y_j + \beta_2 X_i + \beta_3 X_j + \beta_4 Z_j + \epsilon_i \quad (3)$$
$$Y_j = \alpha_1 Y_i + \alpha_2 X_j + \alpha_3 X_i + \alpha_4 Z_j + \epsilon_j \quad (4)$$

- Estimate (3) using two-stage least squares (2SLS)
  - Regress Y_j on Z_j (and X's) and get the predict value $\hat{Y}_j$.

$$\hat{Y}_j = Z\hat{\alpha} = Z(Z'Z)^{-1}Z'Y_j$$

  - Regress Y_i on $\hat{Y}_j$ (and X's).

$$\hat{\beta}_1 = (\hat{Y}_j'\hat{Y}_j)^{-1}\hat{Y}_j'Y_i = \beta_1 + (\hat{Y}_j'\hat{Y}_j)^{-1}\hat{Y}_j'\epsilon = \beta_1 + (\hat{Y}_j'\hat{Y}_j)^{-1}Y_j'Z(Z'Z)^{-1}Z'\epsilon$$

- For the IV method to work, the IV has to satisfy two conditions.
  - Relevance condition: $\mathrm{Cov}(Z_j, Y_j) \neq 0$. Namely, $\hat{\alpha} \neq 0$.
  - Exclusion condition: $\mathrm{Cov}(Z_j, \epsilon_i) = 0$.

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More on IV

- The social contagion model is a variant of the spatial autoregressive model (Anselin et al. 1996; OMalley and Marsden 2008; An 2021).

$$\boldsymbol{Y} = \beta \boldsymbol{WY} + \boldsymbol{X\lambda} + \epsilon \quad (5)$$

  $\boldsymbol{W}$ is a row-normalized adjacency matrix.
  - Modeling effects from multiple peers. $Y_i = \sum_{j \neq i} w_{ij} Y_j$
  - IVs for $\boldsymbol{W}$ based on exogenous networks (Estrada et al. 2021).
- IV software
  - Continuous outcome and continuous treatment (endogenous variable): systemfit (Henningsen and Hamann 2015, 2007) in R and ivregress and ivregress2 (Wada 2012) in Stata
  - Binary outcome and continuous treatment: ivprobit in R (Taha 2018) and Stata
  - Binary outcome and binary treatment: binom2.rho of VGAM (Yee 2015a,b) in R and biprobit in Stata
  - Binary/continuous outcome and binary treatment: LARF in R (An and Wang 2016) and Matlab (Abadie 2003)

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Example: An (2015)

Examples of IVs: Preventative attitudes towards smoking, father's smoking status, siblings smoking status, relatives sick bc of smoking, cigarettes kept at home, distance to nearest store

Table 3. Estimated Effects of Best Friend's Smoking Status on Respondent's Smoking Status

	A. Self-reported Smoking Status				B. Refined Smoking Status			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	OLS-1	OLS-2	2SLS-1	2SLS-2	OLS-1	OLS-2	2SLS-1	2SLS-2
Best Friend's Smoking	0.16**	0.12**	0.20**	0.34	0.25**	0.21**	0.40***	0.41**
	0.04	0.04	0.08	0.23	0.06	0.07	0.07	0.17
Endogeneity test			0.49	0.65			0.14	0.45
Adjusted R-squared	0.20	0.20	0.20	0.17	0.27	0.27	0.25	0.25
Observations	2,049	1,970	1,479	1,479	2,049	1,970	1,479	1,479

Note: OLS-1 shows the estimates when friend selection is not accounted for while OLS-2 shows the estimates when friend selection is accounted for. 2SLS-1 shows the estimates based on the original IVs and 2SLS-2 shows the estimates based on only the empirical IVs. For conciseness, the coefficients for other covariates are not shown. Standard errors are clustered at the school level and reported below the coefficients. Endogeneity test shows the P value testing the null hypothesis that best friend's smoking status is exogenous. Significance pattern: *** P < 0.01, ** P < 0.05, * P < 0.1.

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less likely to reject $\beta_1 = 0$ / true $\beta_1 \neq 0$

- Break Y_j into two parts
  Endogenous/ selection, context
  Exogenous
  - Use this as version of Y_j
  - Part of Y_j affected by $Z_j \rightarrow \hat{Y}_j = f(Z_j)$
  - can have multiple Z_j
  - the more Zs you have, the more assumptions you need so 1 is better

Replace Y_j with $\hat{Y}_j$

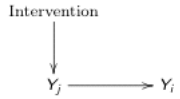
Relevance condition — Z must cause Y_j

Solution II: Experiments

option if can't find IVs

Two types of experiments:

- Randomize contacts
  - Sacerdote (2001) found that randomly assigned roommates and dormmates had significant impact on the GPA of students in a college and their decisions to join social groups such as fraternities.
- Randomize contact's behavior (An 2015, 2018).
  - Interventions that target friend's behavior but not ego's.
  - Changes in ego's behaviors serve as evidence for peer effects.



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