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RPAD 637
Social and Organizational Networks in Public Policy, Management, and Service Delivery: Theory, Methods, and Analysis

Summaries for week 5 – Centrality and Centralization

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- Graph theory in SNA helps to identify ‘most important’ actors in social network.
- Measures designed to highlight difference between important and unimportant actors
- Actors who are the most important or the most prominent are usually located in strategic locations within the network
- Both centrality and prestige indices are measures of prominence or importance of actors in social networks.
- Chapter is divided into two parts:
  - Centrality measures for non directional relations
  - Centrality and prestige measures for directional relations
- Directional relations: Two types of actor and group measures, based on centrality and prestige
- Nondirectional relations: One type, based on centrality
- Differences between the measures shown by three graphs:
  - Star graph
  - Circle graph
  - Line graph

Prominence: Centrality and Prestige

- Prominence: An actor is prominent if the ties of the actor make the actor particularly visible to the other actors in the network
- To determine which of the g actors in a group are prominent, one needs to examine not only all ‘choices’ made by an actor and all ‘choices’ received, but also indirect ties.
- Knoke and Burt (1983) equate prominence to visibility and distinguish two types of visibility or two classes of prominence:
  - Centrality
  - Prestige

Actor Centrality

- Prominent actors are extensively involved in relationships with other actors and are more visible than others.
- In non-directional relations there is no distinction between receiving and sending.
- For non-directional relations a central actor is defined as one involved in many ties.
- Notation: C
- Actor centrality index = \( C_A(n_i) \)
  - C denotes a particular centrality measure, which will be a function of a specific \( n_i \) and A is a generic measure. The index \( i \) will range over the integers from 1 to \( g \)

Actor prestige

- Prestigious actor: one who is the object of extensive ties, thus focusing solely on actor as a recipient.
- Prestige more refined concept than centrality yet difficult to quantify (prestige of an actor increases as he becomes object of more ties but not necessarily when he initiates the ties).
- To study an actor’s prestige we need to focus on ties directed to the actor.
- Prestige can only be quantified for directional relations
- Term prestige can be misleading if the relation is negative
- Prestige can also be called status, rank, deference and popularity.
- Notation: P

Group centralization and group prestige
- Group level measures allow us to compare different networks easily.
- Group level index of centralization
  o Shows that the larger it is, the more likely is it that a single actor is quite central, with the remaining actors are considerably less central
  o Measures how variable and heterogeneous the actor centralities are
  o Records the extent to which a single actor has centrality
  o Measures how unequal the individual actor values are
  o Roughly a measure of variability, dispersion or spread.
- The star graph is maximally central: one central actor has direct contact with all others, who are not in contact with each other.

Non-directional relations
- Single set of actors and a single, dichotomous non-directional relation measured on a pair of actors
- Example: Marital relation between Florentine families (sociogram p 104)

Degree centrality
- Actor centrality: central actor must be most active i.e. have most ties to other actors in the network (Compare actors in star graph to circle graph).
- The very active actor has maximal centrality index. We measure activity as degree

Actor Degree centrality
Centrality measure of an actor is the degree of the node \( d(n_i) \)
- \( CD(ni): \) actor-level degree centrality index
- \( CD(ni)=d(ni)=xi+ =\sum xij =\sum xji \)
- \( C’D(ni) = d(ni)/g-1 \)

- An actor with a high centrality level, as measured by its degree, is ‘where the action is’ in the network.
- This measure focuses on most visible actors in the network
- The actor with large degree is in direct contact or is adjacent to many other actors. He is recognized by others as a major channel of relational information, a crucial cog in the network, occupying central location.
- Actors with low degrees are peripheral in the network.
- Removing an isolated actor with \( d(n_i)=0 \) has no effect on the ties that are present.
Related index:
- ‘ego density’ for a nondirectional relation is the ratio of the degree of an actor to the maximum number of ties that could occur.
- ‘Span’ of an actor is the percentage of ties in the network that involve the actor or the actors that the primary actor is adjacent to. In a star graph the central actor has a span of unity.

**Group Degree Centralization**
- A centralization measure quantifies the range and variability of the individual actor indices. The set of degrees that represents the collection of actor degree indices can be summarized in a variety of ways:

\[ CD = \sum_{g} \left[ CD(n^*) - CD(n_i) \right] / \max \sum_{g} \left[ CD - CD(n_i) \right] \]

Where \{CD(n_i)\} are the g actor degree indices, while CD(n*) is the largest observed value.

- Another standard statistical summary of the actor degree indices is the variance of degrees:
  \[ S^2_D = \frac{\sum_{g} \left( CD(n_i) - \text{mean degree CD} \right)^2}{g} \]

**Closeness Centrality**
- The second view of actor centrality is based on closeness or distance
- Measure focuses on how close an actor is to all the other actors in the set of actors.
- How quickly can an actor interact with all others (e.g., information sharing - short communication paths)
- Central nodes in a network have minimum steps when relating to other nodes i.e. the geodesics / shortest paths must be as short as possible.
- Researchers equate closeness with minimum distance
- Centrality is inversely related to distance (e.g., star graph)

**Actor Closeness Centrality measures:**
1. Sabidussi (1966): actor closeness should be measured as a function of geodesic distances
   - Depends on direct and indirect ties, especially when any two actors are not adjacent.
   \[ C_C(n_i) = \left[ \sum_{j=1}^{g} d(n_i, n_j) \right]^{-1} \]
   - The subscript C is for ‘closeness’. The index is the inverse of the sum of the distances from actor \( i \) to all the other actors.
   - At a maximum, the index equals \( g - 1 \), which arises when the actor is adjacent to all other actors.
   - At a minimum, the index attains the value of 0 in its limit, which arises whenever one or more actors are not reachable from the actor in question
2. The *Jordan Center* of a graph is the subset of nodes that have the smallest maximum distance to all other nodes. Take \( g \times g \) matrix of geodesic distances between pairs of nodes. All nodes that have this smallest maximum distance are part of the center of the graph.

3. The *centroid* of a graph is based on the degrees of the nodes, most appropriate for graphs that are trees. Consider all branches or paths emanating from each node, and define the weight of each branch as the number of lines in it. The weight of a node is the maximum weight of any branch at the node. The centroid is the subset of all nodes that have the smallest weight.

**Group Closeness Centrality:**

Measuring of group centralization by using actor closeness centralities

- Index of group closeness (Freeman 1976)

\[
C_c = \frac{\sum_{i=1}^{g} [Cc(n^*) - Cc(n_i)]}{[(g-2)(g-1)/(2g-3)]}
\]

\( [Cc(n^*)] \) is the largest standardized actor closeness in the set of actors.

\( [(g-2)(g-1)/(2g-3)] \) is the maximum possible value for the numerator.

**Betweenness Centrality**

- An actor is central if it lies between other actors on their geodesics
- Large ‘betweenness’ centrality: the actor must be between many of the actors via their geodesics
- Strategic importance of locations on geodesics

**Actor Betweenness Centrality**

- Stress: In order for actor \( i \) to contact actor \( j \), they must use actor \( k \). Actor \( k \) in this network has responsibility to actor \( i \) and \( j \). Counting minimum paths of which pass through \( k \), we can measure the stress \( k \) must undergo in this network.

- The actor betweenness index for \( n_i \) is the sum of the estimated probabilities over all pairs of actors not including the \( i \)th actor

\[
C_{g}(n_i) = \sum_{j \neq i} \frac{g_{jk}(n_i)}{g_{jk}}
\]

Standardized

\[
C'_{g}(n_i) = \frac{C_{g}(n_i)}{[(g-1)(g-2)/2]}
\]
**Group Betweenness Centrality**

Group centralization indices based on betweenness allow comparing different networks with respect to the heterogeneity of the betweenness of the members of the networks

\[
C_B = \frac{2\sum_{i=1}^{g} [C_B(n^*) - C_B(n_i)]}{[(g-1)^2(g-2)]}
\]

The maximum possible value for this sum is \(\frac{[(g-1)^2(g-2)]}{2}\)

**Information centrality**

**Actor Information Centrality:**

\[
C_i(n_i) = \frac{1}{Cii + (T-2R)/g}
\]

This version of centrality focuses on information contained in all paths originating with a specific actor. The information of an actor averages the information in these paths, which in turn is inversely related to the variance in the transmission of a signal from one actor to another.

**Group Information Centralization**

\[
\bar{C}_I = \sum_{i} C_i(n_i)
\]

**Directional Relations**

- Centrality indices for directional relations focus on choices made
- Prestige indices generally examine choices received, direct and indirect
- Extend four centrality indices, degrees, closeness, betweenness and information to directional relations.
- The centrality indices for degree and closeness are easily applied to directional relations.
- Betweenness and information are not easily applied to directional relations because of their reliance on nondirected paths and geodesics

- **Degree:** Same properties as degree indices for nondirectional relations; exception: when it only focuses on the outdegree of an actor
- **Closeness:** Definition of the distances between any two actors, the length of the geodesics from \(n_i\) to \(n_j\)
  - Influence range of \(n_i\) as the set of actors who are reachable from \(n_i\)
  - Distances from actor \(i\) to the actors in its influence range

**Prestige (choices received)**
Degree Prestige
- The simplest actor-level measure of prestige: the indegree of each actor
- Actors who are prestigious tend to receive many nominations or choices
- $PD(n_i) = dl(n_i) = X+i$

Proximity Prestige
- Proximity is defined as closeness that focuses on distances to rather than from each actor
- Index $P’D(n_i)$ counts only actors who are adjacent to actor $i$
- Influence domain of actor $i$ can be defined as the set of actors who are both directly and indirectly linked to actor $j$
- Such actors are reachable to $i$, or alternatively, are those from whom $i$ is reachable

Status Rank or Prestige
- Numbers of direct ‘choices’ or distances need to be combined to a specific actor, with the status or rank of the actors involved
- Ex: one’s influence domain is full of prestigious actors; one’s prestige should also be high. If an actor’s domain contains only peripheral or marginally important actors then rank of the actor should be low.

- Developed a simple theory of power relations to resolve the ambiguities surrounding ‘power’ and ‘authority’.
- The systematic treatment of social power is blocked by a recurrent flaw of treating power as an attribute of a person or group (X is an influential person)
- Emerson argues that power is a property of the social relations; it is not an attribute of the actor.
- X has power is vacant, unless we specify ‘over whom’.

Assumptions
- Applicable to small groups or complex communities
- Attention is focused on characteristics of relationship rather than personal traits / skills
- Actors can be a person or group
- Party A depends on B, if A aspires goals whose achievement is facilitated or hindered by B’s actions.
- Ties of mutual dependence - each party is in a position to grant or deny the other’s gratification
- Power resides implicitly in the other’s dependency
- Goals are gratifications consciously sought as rewards and unconsciously obtained through relationships.

The power-dependence relation between a person A and person B

Dependence (Dab): Dependence of actor A on actor B is directly proportional to A’s motivational investment in goals mediated by B, and inversely proportional to the availability of resources to A outside of the A-B relation.

Power (Pab): The power of actor A over B is the amount of resistance on the part of B, which can be potentially overcome by A (not necessarily observable but can be tested and explored).

Pab = Dba: Therefore, the power of A over B is equal to the dependence of B on A.

Therefore, formal equations of power-dependence relations, recognizing the reciprocity between social relations, are:

Pab = Dba: the power of A over B is equal to the dependence of B on A
Pba = Dab: the power of B over A is equal to the dependence of A on B
- Reciprocity of power implies equality and inequality of power in the relation \( P_{ab} = P_{ba} \)?
- Non-emergence of dominance does not imply inoperative power
- There would be a balanced relation or an unbalanced one

\[
\begin{align*}
\text{Pab} &= \text{Dba} \\
\text{Pba} &= \text{Dab}
\end{align*}
\]

- Balance does not neutralize power, for each party might continue to exert profound control over the other.
- The powerful actor A could enjoy a power advantage deriving from differential power (\( P_{ab} - P_{ba} \)) which can be positive or negative

- Unbalanced relation is unstable, and tensions involved in unbalanced relation might not be endured. They can be reduced either through cost reduction or balancing operations.
- ‘Cost’ amounts to the ‘resistance’ to be overcome.
- Cost reduction refers to the process of value adjustment or changing values in order to reduce the pain incurred in meeting A’s demand.
- Cost reduction will take place even under balanced conditions

- Emerson emphasizes 4 types of balancing operations rather than cost reduction because balancing operations can change the fundamental power relations while cost reduction can’t.
- e.g. children playgroup, A and B in a balanced relation, equally motivated towards collective playing. C moves into neighborhood, befriends A and not B. The power relation between A and B becomes unbalanced).

**Operation 1- Withdrawal**
The tension in unbalanced A-B relation can be reduced through the motivational withdrawal of B, for this will reduce Dba and Pab. So, the denial of dependence on A will have effect of moving B away from relations.

**Operation 2- Extension of power networks**
The second operation takes place through alterations in the structure of power network (two or more connected power- dependence relations), by connecting other actors. The network will be extended by formation of new relationship or closing of network ( \( B-A-C \Rightarrow adding B-C \) or \( B-D C-E \), forming relation with additional children D or E)

**Operation 3- Emergence of status**
The third operation increases the weaker member’s power to control the formerly more powerful member through increasing the latter’s motivational investment in the relation. This can be achieved by “status giving”, giving powerful actor ego-rewards like prestige or statue recognition, which are highly valued by others. This balancing operation results in increasing the dependence of A on B and C, so increases Pba or Pca.
**Operation 4 - Coalition formation**
A triadic network C-A-B, reduces to a coalition is two weaker members (B,C) unit as a single actor in dealing with the power actor A.
It collapses the two relational network into one group- person relations with emergence of ‘collective actor’.

**Authority**
Authority is more than balanced power. It's directed power which can be employed (legitimately) only in channels defined by the norms of the group. It emerges as a transformation of power in a process called legitimation.
To resolve and clarify some of the conceptual problems of centrality, by focusing on the structural properties of human communication networks.

**Adjacent:** When two points are connected by an edge

**Degree:** The number of other points to which a given point is adjacent

**Reachable:** An unordered pair of points (pi and pj) is reachable if there exists a path i.e. a sequence of one or more edges. The path begins at pi, passing through intermediate linking points and ending at pj.

**Cycle:** A path that begins and ends at the same point is called a cycle e.g. (p2,p3) (p3, p4) (p4, p2).

**Connected:** When every point is reachable from any other point the graph is called connected.

**Geodesics:** The shortest paths linking a given pair of points

**Point centrality**

Figure 2. *A star or wheel with five points.*

<table>
<thead>
<tr>
<th>Structural properties of the center of the star:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Maximum possible degree</td>
</tr>
<tr>
<td>- Falls on the geodesics between the largest possible number of points</td>
</tr>
<tr>
<td>- Maximally close to all points, as located at the minimum distance from all other points.</td>
</tr>
</tbody>
</table>

**Within communication networks:**

- Centrality was seen as degree
- To be ‘in the thick of things’.
- Focus on visibility
- Focal point of communication
- Major channel of information

**Measure of point centrality based on degree**

\[ C_D(p_k) = \sum_{i=1}^{n} a(p_i, p_k) \]

Where \( C_D(p_k) \) is large is \( p_k \) is adjacent to or directly in contact with a large number of points. It would be zero for a point that totally isolated.

**Betweenness**

Second way to view point centrality is based on the frequency with which a point falls between pairs of other points on the shortest or geodesic paths connecting them. (p3 shows maximum betweenness)

Person is central:
- Strategically located on the communication paths linking pairs of others
- Can withhold or distort information in transmission
- Potential for control

**Measure of point centrality based on betweenness**

\[ C_B(p_k) = \sum_{i=1}^{n} \sum_{j<i} b_{ij}(p_k) \]

The sum \( C_B(p_k) \) is an index of the overall partial betweenness of point \( p_k \). Whenever \( p_k \) falls on the only geodesic connecting a pair of points, \( C_B(p_k) \) is increased by 1. Maximum value of \( C_B(p_k) \) is achieved only by central point in a star.

**Closeness**

Third way to view centrality is based on the degree to which a point is close to all other points in the graph.
(in star graph, p3 is only at a distance of one from each of the four other points)

Person in center:
- Control of communication
- Can avoid control potential of others (fig 2, p3)
- Not dependent on others as ‘relayers’ of information/ messages
- (fig 1, p2 is dependent on p4 to pass message to p5)

**Measure of point centrality based on closeness**

\[ C_C(p_k)^{-1} = \sum_{i=1}^{n} d(p_i, p_k) \]

\( d(p_i, p_k) \) is the number of edges in the geodesic linking \( p_i \) and \( p_k \).
Centrality of a point is measured by summing the geodesic distances from that point to all other points in the graph. It is actually measure of point decentrality or inverse centrality.

<table>
<thead>
<tr>
<th>Structural attribute</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication activity</td>
<td>Degree</td>
</tr>
<tr>
<td>Control of communication</td>
<td>Betweenness</td>
</tr>
<tr>
<td>Interdependence or efficiency</td>
<td>Closeness</td>
</tr>
</tbody>
</table>

**Graph centrality**

Measure based on degree

\[
C_D = \frac{\sum_{i=1}^{n} |C_D(p^*) - C_D(p_i)|}{\max \sum_{i=1}^{n} |C_D(p^*) - C_D(p_i)|}
\]

Measure based on betweenness

\[
C_B = \frac{\sum_{i=1}^{n} |C_B(p^*) - C_B(p_i)|}{n^3 - 4n^2 + 5n - 2}
\]

Measure based on Closeness

\[
C_C = \frac{\sum_{i=1}^{n} |C_C(p^*) - C_C(p_i)|}{(n^3 - 3n + 2)(2n - 3)}
\]

“…Proposes a generalization of the concept of centrality that accounts for both the usual positive relationship between power and centrality and Cook et al.’s recent exceptional results”

- Conventional thinking – in bargaining situations, those with connections to others with many other connections is most advantageous
  - more connections exchange partner has, more options for initiator → power
- Bonacich’s thinking – those with connections to others with few options is most advantageous
  - The more connections partner has, more options, but less bargaining power for initiator of exchange
  - The fewer connections exchange partner has, more power for initiator

**Measurements and Math**

- Proposes a measurement of centrality by summing the unit’s connections to others, weight by the centralities of the others
- Standard centrality of a unit
  \[
  \lambda e_i = \sum_j R_{ij} e_j,
  \]

- In terms of \(c(\alpha, \beta)\), centrality becomes
  \[
  c(\alpha^\gamma, \beta) = \alpha \sum_{\gamma=0}^{\infty} \beta^\gamma V_{\gamma+1} I = \alpha (V_1 I + \beta V_2 I + \beta^2 V_2 I + \cdots)
  \]

- The total number of communications caused by each individual is
  \[
  \sum_{k=1}^{\infty} \beta^{k-1} R^k I = \sum_{k=0}^{\infty} \beta^k R^{k+1} I = c(1, \beta),
  \]

- Low values of beta indicate more localized power, higher values indicate more global power → helps identify number of ties others have to more actors in the network
  - The less paths of two, centrality and power are increased
  - The more paths of two, centrality and power are reduced

**What does it mean?**

- Differs from other mathematical determinants of centrality because objective is to identify the least amount of connections bargaining partners have with others
  - Focus is more on dyadic relations rather than larger relations
- Empirical analysis based on Cook et al.’s findings

*Refer to the article for how the equations were specifically derived*

- Deals with two theoretical traditions
  - Point centrality in graph-theoretic representations of structure as an approach to power distributions
  - Power dependency principles applied to exchange networks
- Discusses issues with lack of generality, offers two theoretical points regarding power in exchange networks and bargaining networks
  - A distinction between two different principles of “connection” in social networks suggests that current measures of centrality might predict power in one type of network, but not in the other
  - Offers a first step toward a fusion of power-dependence theory and structural centrality in a way which might be general across networks of both types

Exchange networks
- Involve transfer of valued items
- Specific social structure formed by two or more connected exchange relations between actors
- Connection is defined as
  \[ \text{Definition 1: Two exchange relations between actors A-B and actors A-C are connected to form the minimal network B-A-C to the degree that exchange in one relation is contingent on exchange (or nonexchange) in the other relation. (a) The connection is positive if exchange in one relation is contingent on exchange in the other. (b) The connection is negative if exchange in one relation is contingent on nonexchange in the other.} \]
- Emphasis on positive v. negative connections
  - Ex. Dating and friendship networks are negative $\rightarrow$ reciprocation is not a necessity
  - Ex. Sales of merchandise or positive $\rightarrow$ money is exchanged for a good

A few notes on boundaries
- Network connections – allow boundaries or concrete networks to help develop a theory in which events at any point in the network has cascading repercussions within the network boundaries
- Because boundaries are not usually consensual, actors can be viewed as relatively autonomous decision makers occupying “positions” in the network structure extending beyond what they are aware of

Positions in an exchange network
- Position in graph theory terms
  \[ \text{Definition 2: A position in a graph or network is a set of one or more points whose residual graphs are isomorphic.} \]
- Actors are points on the graph, relations are lines
• Residual graph – obtained by the removal of a specific point from a “parent” graph
• Cook et al. argue that the distribution of power can be studied as a function of position in an opportunity structure
  o Power use can be measured in terms of the actual benefits obtained through negotiation within the opportunity structure

Structures studied in the research

1(a) 4 person network (two positions)  
1(b) 4 person network (one position)  
1(c) 5 person network (three positions)  
1(d) 7 person network (three positions)  
1(e) 10 person network (three positions)  
1(f) 13 person network (three positions)

Centrality and power in negatively connected exchange networks
• Question of “Do predictions based on power-dependence notions and those based solely on structural centrality yield the same results in negatively connected networks?”

Point centrality
• Degree-based measures – a count of the number of adjacent points
  o Dismissed as inadequate in determining power relations
• Betweenness measures – based on the “frequency with which a point falls between pairs of other points on the shortest paths connecting them”
  o Accepted because it plays central role in connecting actors
• Closeness-based measures – indexes of the extent to which a particular point is “close” to all other points; counts the number of edges or lines in the paths linking two points
  o Accepted because it relates actors beyond dyadic relationship to a central actor

*Hypothesis 1:* In the network portrayed in figure 1c, D > E, > F, in power if either closeness or betweenness-based measures of point centrality are used.

• Hypothesis 1 offered because
  o Structural principles are desirable in order to advance exchange network theory
  o Point centrality appears to be the best currently available candidate because of its relation to power
  o Makes explicit the predictions which the best measures of point centrality would make, if applied to the networks under study

**Power and confidence**

*Definition 3:* In any dyadic exchange relation A; B, (where A and B are actors, and x and y are resources introduced in exchange), the power of A over B (P_AB) is the potential of A to obtain favorable outcomes at B’s expense.

*Definition 4:* The dependence (D_AB) of A on B in a dyadic exchange relation (e.g., A; B,) is a joint function (1) varying directly with the value of y to A, and (2) varying inversely with the availability of y to A from alternate sources.

• Essentially, fundamental relationship between power and dependence is PAB = DAB
• Three unambiguous predictions concerning the locus of power in negatively connected networks

*Hypothesis 2:* As the exchange process proceeds through time, the occupants of position E will display more power use than the occupants of positions F and D. This display of greater power use will take two forms: (a) an increase over time in the amount of benefits received from exchange at position E, and, as a result, (b) a greater absolute level of exchange benefit obtained by the occupant of position E by the final exchange phase.

*Hypothesis 3:* The differential power use of E over F will be displayed before the power use of E over D (since the latter process is, in theory, predicted to be a result of E’s power use over F).

*Hypothesis 4:* In the final or stable phase of power use, the occupants of position E will exert equal levels of power over the occupants of positions F and D.
• Reasoning behind the hypotheses:
  o In negatively connected networks, any two lines joined at a point provide that point with “alternative sources” of value
  o While positions D & E have equal access to resources, each having two valuable partners, their partners do not have equal exchange opportunities
• If the incentive to exchange is high throughout the network, position will create differentials in resource availability \(\rightarrow\) power and dependency levels are unequal
• If the incentive to exchange is low throughout the network, differentials in resource availabilities will be low \(\rightarrow\) power and dependency will be more equal

_Hypothesis 5:_ The effects implied in hypotheses 2, 3, and 4 will be more pronounced under conditions of high exchange incentive than under conditions of low exchange incentive.

**Power as potential, power use, and equilibrium**
• In the context of the research, the less powerful actor could receive no more benefit from the more powerful actor than is obtainable from the best alternative source
• If there are restraints on the exercise of power, equilibrium will be reached somewhere short of this maximally “exploitive” exchange ratio
• Relative availability of resources from alternate sources determines relative positional dependence
• Relative positional dependence across the network of connected exchange relations determines power

**Theoretical strengths and deficiencies**
• Has the virtue of being closely coordinated with concrete behavioral concepts and observations
• Link between centrality and power is largely intuitive
  o Graph-theoretic networks centrality have been related to are loosely coordinated with social interaction

**Experiment and experiment structure**

Briefly, subjects were recruited from undergraduate classes and campus newspaper ads. Emphasis was placed on the desire to earn money as a motive for taking part in the experiment. After a brief collective orientation, each subject was taken to a private room containing a computer terminal. All terminals are joined to a minicomputer in the laboratory which is programmed to allow certain terminals to communicate with certain other terminals. This procedure gives the experimenter control of the network of exchange opportunities.

• Principles of equity were prevented from operating to allow for natural progression of power and centrality
Discussion

- Two of the best conventional measures of point centrality failed to soundly predict the distribution of power
- Two conclusions
  - A more general conception of point centrality needs to be developed or applied only in certain types of networks
  - Power dependency theory needs to be raised to the macroscopic level of analysis
- Two suggestions
  - A measure of system-wide dependence on a given position in a network will turn out to be a measure of “centrality” of that position
  - Power at the position can easily be interpreted through power dependency theory

Dependence and network vulnerability

- Question: To what extent does the flow of valued resources within an N-actor network depend on facilitating exchange behavior by the occupants of a given position in that network?
- Vulnerability – vulnerability of the network to the removal of a given point or line
  - Removal – any form of substantial withdrawal from the network
  - Concept of “point vulnerability” – element in which if a point is removed, the residual graph has weakened or impaired resource flows
- Vulnerability in a negatively connected network locates the points of minimum dependence, equivalent to maximum network-wide power → positions in a relatively “powerless” in a network to the extent that they have few exchange opportunities and have direct connections only to actors who have highly reliable alternative sources of supply
- A “betweenness” measure of point centrality in positively connected networks is consistent with the notion of point vulnerability

Conclusion

- “Decentralization” principle – exchange networks tend to form into systems organized around multiple foci of power, “regional centers” (figure 1, Point E)
- Existing point centrality measures are not applicable to negatively connected exchange networks
- “Centralization” is more likely to occur than decentralization

- Shows that occupying a broker position in communications networks within the US health policy domain is a crucial element of influence
- Argues that occupancy of brokerage positions, coupled with impartiality with respect to private interests, is a central and constitutive element of state power
- Concludes that influence of government organizations is contingent on their capacity to link disparate actors in the communication network while remaining uncommitted to specific policy agendas
- Brokerage – the occupancy of a structural position that links pairs of otherwise unconnected actors

**Theoretical conception of brokerage**
- Brokers play different roles depending on the group to which they belong
- Liaison – brokerage relation in which all actors occupy different groups
- Representative – serves as a representative of a larger group
- Gatekeeper – an actor screens or gathers resources from the outside and distributes them to members of his or her own subgroups
- Itinerant/Cosmopolitan – broker belongs to one subgroup while the other two belong to a different subgroup
- Coordinator – actor leads other actors of the same group
Brokerage and influence in policy domains

- Two reasons why ability to establish indirect links should be crucial in policy domains
  - There are simply too many actors and organizations in the environment making it extremely unlikely that effective communication ties can be maintained
  - May link pairs of actors who need to communicate as a result of specific policy initiatives that unexpectedly makes other interests independent

Hypothesis 1.—For all five brokerage types, actors who control two-step paths between pairs of other actors are perceived as more influential, on average, than actors who do not.

Hypothesis 2.—Among government organizations, the relationship between influence and occupancy of liaison and itinerant brokerage positions will be attenuated by a tendency to take stands on policy events.

Hypothesis 3.—Among government organizations, the relationship between influence and occupancy of representative and gatekeeper brokerage positions will not be attenuated by a tendency to take stands on policy events.

Hypothesis 4.—For nongovernment organizations, the relationship between influence and liaison, gatekeeper, representative, and itinerant brokerage position will be unaffected by advocacy of specific policies.

Hypothesis 5.—Taking stands on policy events will contribute to the influence of coordinators, whether or not they are government organizations.

Data and methods

- Based on national health policy domains during the Carter administration
- Use of questionnaires, rosters, free recall, archival records
- “Influence reputation” as dependent variable
  - Reputation is a resource
  - Past studies identify reputations as a reliable measure
  - Greatly related to brokerage power and leverage
- Brokerage in this case is a variant of betweenness centrality
- Distinguish among government organizations, profit-seeking organizations, and voluntary associations

Findings

- Hypothesis 1 - Data indicates that brokers occupy multiple brokerage types and are positively related to influence reputation
- Hypothesis 2 – influence is reduced for each additional stance taken on policy events
- Hypothesis 3 – influence is not weakened by a record of taking stands on policy events
- Hypothesis 4 – none of the interaction terms between taking a stand and brokerage positions were unaffected
- Hypothesis 5 – regression models confirm the hypothesis
Discussion and conclusions

- Nongovernmental organizations are better able to promote their private agendas to the extent that they have extensive connections both to government actors and to other private-sector actors
- Government actors with records of stands on policy events derive less influence
  - Impartiality is needed to maintain influence
- Occupancy of coordinator position in government organizations is associated with greater influence when actors take stands on policy events
- Occupancy of coordinator position in nongovernment organizations is associated with neither more or less influence when actors take stands on policy events
Introduction
This article uses social network analysis methods to explain the Rise of the Medici at the beginning of the XV century. In general, it is argued that the centrality of the Medici family in the social networks of the elite Florence families explains the rise of the Medici party to power and, most importantly, the political centralization processes that led to the birth of the Renaissance state in Florence. The article explores the dynamics in the network of elite families that made the Medici central to the network and the Medici party more powerful.

Methodology
The authors collect information (mostly from previous research) about the different relationships between 215 Florentine elite families identified but, for most of the analysis 92 families are used because there was not enough information available for all the families.

The following nine different relations are recorded: Kinship: (1) Marriage; Economic: (2) Trading, (3) partnership, (4) bank employment, (5) real estate ties; Political: (6) Patronage, (7) personal loans; Personal: (8) Friendship, (9) surety ties.

Additionally, data on the attributes of the different families is recorded. Three attributes are important to the analysis: (1) Political Party affiliation: Medician, Oligarchs or Neutral, (2) political age of the family: Patricians vs. New Men and (3) Neighborhood: name of neighborhood where they live.

With all this information, they use a technique that we haven’t learned (but according to the syllabus, we will!) that is block modeling. They aggregate the different actors into structurally equivalent sets and end up with a reduced number of blocks. A relation between two blocks is present if there are two or more links in between the families that constitute the blocks.

Results
The structure of the different relations is mapped by the authors and the kinship (marriage) and economic relationships, considered strong ties or structural relations, prove to be the most revealing. Figure 2a shows the structure of these relationships.
Several findings can be derived from this blockmodel structure:

1. “The capacity of marriage and economic blockmodels to predict political partisanship is remarkable” (pg 1275). The triangulated circle seen on the top of the image represents the blocks associated to the Medician party while the remaining families on the bottom that form a rectangle are the Oligarch party blocks. Primarily, this shows how the structure of marriage and economic relations was central to the formation of parties in Florence.

2. “The Medici party was an extraordinary centralized, and simple “star” or “spoke” network system, with very few relations among Medici followers: the party consisted almost entirely of direct ties to the Medici family” (pg 1278). The authors estimate one of the group centralizations statistics (betweenness) and find that the $C_B$ for the Medicin network was .362 (marriage relations) and .429
(economic relations) while the group betweenness of the oligarchs was .184 (marriage) and .198 (economic).

3. Not only the members of the Medician network were connected between them only by the Medici family, they were also only connected to the rest of the elite (oligarchs) through the Medici family.

4. Look at the Oligarch blocks and the density of their relationships compared to the density of the relationships of the Medician block. In this case, the density of the Oligarchs proved to be a problem because “the oligarchs were composed of too many status equals, each with plausible network claims of leadership” (pg 1279).

5. Finally, a careful analysis of the types of ties of the Medici reveals that they do not have both economic and kinship relationship with the same blocks. The either have an economic relation or a kinship relation but not both.

After describing the elite network and showing how the Medici family was central, the authors analyze the dynamics that placed the Medici on the center.

**How did the Medici become the center of the network?**

The answer to this question is closely related with the point 5 discussed above. They were exclusively linked with some family blocks by marriage and with other family blocks by economic relations. They were linked with other fellow patricians by marriage and to the new men by economic relations. This allowed them to diversify their connections and gain support. The oligarchs, on the contrary, didn’t relate in any way with the new men because they would lose prestige among other patricians and closed their network.

For the Medici, the loss of prestige was not as important because they were already being isolated from the patricians within their neighborhood due to the participation of members of the Medici family in the Ciompi Revolt (a popular revolt by wool carders). This isolation, also led the Medici to look for kinship links with other patricians outside their neighborhood (patricians in their neighborhood wouldn’t marry them) and by doing so diversifying even more their support. Being already isolated from their neighborhood, the prestige costs of associating with new men were low. After the Milan and Luca wars the taxes levied in the neighborhood were the Medici levied were significantly increased on the new men who went to local neighborhood patricians for help; only the Medici would help them. The mechanics briefly explained in this paragraph, ironically explained by the initial isolation of the Medici family, led them to create a diversified network of support base on their economic and kinship relations. This dynamic also kept the density of the Medician network low as their network was diverse (in terms of location and prestige) which kept the different nodes in the network from communicating among them.

**Robust Action**

The action of the Medici, especially of Cosimo de’ Medici, is described as robust because he never disclosed his interests and desires as this would limit the options of the party. Cosimo de’ Medici is described as an “indecipherable sphinx” (pg 1262) and it is precisely this characteristic that helped him build a powerful party. The multivocality and ambiguity of his messages allowed him to gain support both from patricians and new...
men. For instance, the Medici were simultaneously seen as the heroes or the new men and as having deep patrician roots. The oligarchs, on the other side, with a clear message that directly exclude the new men constituted a closed network that wouldn´t expand.

**Conclusion**
The authors stress on how the relationship structures among people can explain complex social processes such as the centralization of power and state formation. “to understand state building, we have argued, one needs to penetrate beneath the veneer of formal institutions and apparently clear goals, down to the relational substratum of people’s actual lives” (pg, 1310).
Introduction
This article studies the dynamics by which network structures create and reproduce gender inequalities in organizations. For doing this, the author reviews the existing literature about how network structure can predict sex differences and derives five hypotheses to be tested with empirical evidence. Before going over the hypotheses, first let’s do an overview of the methodology and some important concepts.

Methodology
The study is based on a survey performed to 79 employees of an advertising company. The survey asked about five different types of relationships between employees: (1) communication, (2) advice, (3) support, (4) influence, and (5) friendship. Influence and advice networks were considered instrumental networks while communication, support and friendship networks were considered expressive networks. Instrumental relations are seen as a mean to an end (more recognition) while expressive relations are more related to the individuals affective needs.

Attribute data for all the participants of the survey is also collected. This data includes gender, prestige, professional activity, tenure, education, rank and department. Additionally, properties of the individual’s choices (homophily and multiplexity) and indices of centrality were calculated for each individual. Homophily is the preference to interact with others of the same sex and multiplexity refers to the variety of the types of interaction (instrumental, expressive).

Results
Before going into the hypotheses, the author shows the following table that summarizes the different correlations among variables. The centrality measures of the five types of relations are significantly correlated with gender.

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<td>.29***</td>
<td>.26**</td>
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<td>-.10</td>
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</table>

*p < .05; **p < .01; ***p < .001.
Now, let’s move to the five hypotheses and the evidence presented to prove (not prove) them.

Hypothesis 1: **Controlling for availability, women will tend to choose women as expressive network contacts but will choose men as instrumental network contacts. Men will tend predominantly to choose men across multiple networks.**

Table 3

<table>
<thead>
<tr>
<th>Differences between Men and Women in Homophily</th>
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<td>Homophily indices</td>
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<td>HComm</td>
</tr>
<tr>
<td>HAdvice</td>
</tr>
<tr>
<td>HSupport</td>
</tr>
<tr>
<td>HInfluence</td>
</tr>
<tr>
<td>HFriend</td>
</tr>
</tbody>
</table>

Means* | (N = 45) | (N = 34) | (N = 79)† |

<p>| | | | |</p>
<table>
<thead>
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<tr>
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<tr>
<td>HFriend</td>
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<td>.14</td>
<td>-2.57*</td>
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</tbody>
</table>

Table 3 shows that, on average, men direct their relationships more to men (positive mean) while women direct all but their friendship relations to the opposite sex (negative mean). The standardized regression coefficient showed on the right further illustrates the significance of gender to explain the homophily indices. It shows that the gender variable was significant when a regression that included the homophily indices as the dependent value and gender and other controls (background characteristics, rank and department).
Hypothesis 2: *Men will have more multiplex network ties, in total than women, as well as more multiplex ties to men than women have to women.*

**Table 4**

| Differences between Men and Women in Multiplexity |
|------------------------|--------|--------|-------------------------|
| Multiplexity indices   | Means  | Unstandardized regression coefficients (N = 79)* |
|                        | Women (N = 45) | Men (N = 34) | T-value | d.f. = 70 | |
| Total multiplexity     | 2.15   | 2.23   | -.63     | .19       |
| Multiplexity of ties   | 2.02   | 2.42   | -2.42    | .64**     |
| to same sex            |        |        |          | (14)      |
|                        |        |        |          | (21)      |

* p < .05; **p < .01.

* Unstandardized coefficients are reported for gender with multiplexity indices as dependent variables. All control variables (i.e., education, tenure, professional activity, prestige, department, rank) are included in the regression model; standard errors are in parentheses.

The evidence partially supports hypothesis 2. Table 4 shows that gender is significant only for explaining multiplexity of ties to the same sex. However, gender does not explain the number of total multiplex network ties. Remember that multiplexity refers to the count of different types of relations; for example the table shows that women have 2.15 average different relations to other nodes in the network.

Hypothesis 3: *Men will hold more central network positions than women in workplace interaction networks.*

Hypothesis 4: *Differences in centrality will be higher in instrumental networks than in expressive networks.*

**Table 5**

| Differences between Men and Women in Centrality |
|-------------------------------|--------|--------|-------------------------|
| Centrality indices            | Means  | Unstandardized regression coefficients (N = 79)† |
|                               | Women (N = 45) | Men (N = 34) | T-value | d.f. = 70 | |
| Communication                 | .26    | .55    | -4.63*** | .04       |
|                               | (3.9)  | (8.7)  |          | (.06)      |
| Advice                        | .10    | .45    | -6.11*** | .06       |
|                               | (2.0)  | (6.8)  |          | (.06)      |
| Support                       | .35    | .59    | -4.68*** | .01       |
|                               | (3.9)  | (7.5)  |          | (.05)      |
| Influence                     | .02    | .21    | -3.53*** | .03       |
|                               | (1.2)  | (6.2)  |          | (.06)      |
| Friendship                    | .32    | .56    | -3.36*** | .02       |
|                               | (2.3)  | (3.9)  |          | (.09)      |

* p < .05; **p < .01; ***p < .001.

* Degree centrality scores, i.e., the raw number of nominations, are reported in parentheses.

† Unstandardized regression coefficients are reported for gender with centrality indices as dependent variables. All control variables (i.e., education, tenure, professional activity, prestige, department, rank) are included in the regression model; standard errors are in parentheses.
Table 5 partially corroborates the two hypotheses (3 and 4). At the left of the table it can be seen that the mean centrality between men and women in the different networks is significantly different. Additionally, it can be seen that the differences are higher in one instrumental network (advice) while in the other instrumental network (influence) the difference is lower than expressive networks (communication, support and friendship). Additionally, when the relationship between gender and centrality for each network is controlled with other attributes (background characteristics, rank and department), it is no longer significant. In other words, the women have less centrality, but this is not explained by the fact that they are women; it is explained by differences in other attributes.

Hypothesis 5: Men will receive greater network returns on their individual and positional resources than women.

Table 6

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Communication</th>
<th>Advice</th>
<th>Support</th>
<th>Friend</th>
<th>Communication</th>
<th>Advice</th>
<th>Support</th>
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</table>

| AVHomophily           | -.11*         | -.62   | -.12**  | -.18*  | .76**         | .52    | .38     | .74    |
| Multiplexity          | .06           | .05    | .04     | .15    | -.07          | -.07   | -.02    | -.03   |
| R²                    | .61***        | .51**  | .60***  | .30    | .80***        | .74*** | .61***  | .39*   |
| ΔR²                   | .06*          | .03    | .15**   | .11*   | .04**         | .02    | .02     | .03    |
| Adjusted R²           | .50           | .37    | .48     | .11    | .73           | .65    | .47     | .17    |

* p < .10; **p < .05; ***p < .01; ****p = .001.

* Unstandardized regression coefficients; standard errors are in parentheses.

Table 6 shows the results of regressions that include all the attribute data as the independent variables and the centrality on each of the networks as the dependent variable. Across the table it can be seen that the returns for each variable (measured by the degree of the coefficient) are higher for men than women. For example, a higher rank (significant at .001 for all the regressions) in the communication network for women has a return of 0.14 for increases in rank while for men it has a return of 0.24.
To further prove hypothesis 5, the author runs a regression (table 7) with all the control variables and an interaction of gender with the significant variables from table 6 as the independent variables and centrality on the different networks as the dependent variable.

**Table 7**

<table>
<thead>
<tr>
<th>Interaction terms</th>
<th>Communication</th>
<th>Advice</th>
<th>Support</th>
<th>Friendship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex • Professional activity</td>
<td>-</td>
<td>.03**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex • Rank</td>
<td>-</td>
<td>.03*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex • AVHomophily</td>
<td>.85*</td>
<td>-</td>
<td>1.19***</td>
<td>1.68***</td>
</tr>
<tr>
<td></td>
<td>(.48)</td>
<td></td>
<td>(.43)</td>
<td>(.79)</td>
</tr>
<tr>
<td>ΔR²</td>
<td>.014*</td>
<td>.02*</td>
<td>.04***</td>
<td>.04***</td>
</tr>
</tbody>
</table>

* p < .10; **p < .05; ***p < .01.

Unstandardized regression coefficients; standard errors are in parentheses. Control variables are the same as in Table 6.

**Conclusion**

The results of this study establish a relationship between network structure and female exclusion. It argues that “sex differences in homophily and rates of return to individual and positional resources operate to create and reinforce gender inequalities in the organizational distribution of power” (pg.444). On one side, men are more likely to form homophilous and multiplex networks while women are more likely to relate with men for their instrumental relations and women for their expressive relations. These dynamics place men on more central positions in the support networks. On the other side, men get higher returns (measured in centrality) to their investments on human capital. This structure creates and reinforces gender inequalities by means of an unequal distribution of power.

**Introduction**

This article explores the relationship between structural variables (at the individual level) and the influence of individuals in networks. Unlike other studies, it focuses specifically on structure characteristics as determinants of individual influence rather than individual attributes. “While personal attributes and strategies may have an important effect on power acquisition, the view adopted in this study is that structure imposes the ultimate constraints on the individual” (pg. 518). To do so, the author evaluates the structural positions of the individuals within different social networks (workflow network, communication network and friendship network) and relates them with influence.

**Methodology**

Sociometric surveys of 140 nonsupervisory employees and their supervisors were conducted in an advertising company. Additionally, the researcher observed the interactions of the employees to make sure the data was reliable. The nonsupervisory questionnaires gathered information to assess the individual position in the network structure (independent variable). Three different networks (workflow network, communication network and friendship network) are analyzed using different units of reference (workgroup, department and organization). The supervisors’ questionnaires and information about the promotion of employees (three years after the survey was conducted) are used to measure the influence (dependent variables).

*Independent variables*

Several variables independent variables are used to assess the position of individuals in the different networks and units of reference. Here is a list of them:

- **Centrality (access and control)** – Measures of closeness and betweenness for all the nonsupervisory employees were estimated. Higher measures of closeness are understood as a decrease of an employee’s dependence on others (access) and higher measures of betweenness is an increase of other dependence on an employee (control). These two variables were estimated for the three networks.
- **Department membership** – Refers to the department in which the nonsupervisory employee works. Some departments are considered more powerful than others.
- **Contacts beyond workflow** – This measures the number of contacts that employees have with other employees that are out of their immediate workgroup or part of their workflow.
- **Dominant coalition** – Measures the communication relations between an employee and some actors recognized to be part of the dominant coalition of the organization. Specifically related to the workflow network three additional independent variables are measured:
  - **Criticality** – Measures if an employee’s task is critical to the flow of work. That is, if others depend on this an employee performing his task.
  - **Transaction alternatives** – Measures the number of alternatives that an employee has to get the inputs or distribute the outputs needed for performing his job.
Distance from boundary- Refers to a position in the workflow network which can translate to power. Employees in boundary spanning positions have to deal with situations in which they have to deal with uncertain situations that allow them to gain power in the network.

**Dependent variables**
Influence is measured according to perception (the ratings of the supervisors, lists of influential employees provided by the nonsupervisory surveys) and data of the promotion of nonsupervisory employees to supervisory levels three years after the survey was conducted.

**Results**
The analysis of the author reports information from the workflow and communication networks (the friendship network was dropped from the analysis due to high correlations with the communication network). Zero-ordered correlations were calculated between all the structural measures (independent variables) and each of the influence measures (dependent variables). The table also reports the regression coefficients (in parenthesis) when all the independent variables are entered in the regression equations.
These results provide a strong support for the expected relationship between structural variables and influence. It can be seen that an important number of the correlations and coefficients are significant and, as expected, positive. For instance, criticality of the work performed by the nonsupervisory employee was significant and positive both for the zero-correlations and for the regressions.

Not convinced by the correlation and regression coefficients of the distance from organizational boundary, the author further analyzed this variable. They differentiated between employees whom, as part of their workflow have to establish contacts outside the organization (boundary-spanning workers) and those whose direct workflow connections are entirely in the organization (technical core personnel). After controlling for this variables it was found that the technical core personnel workers were benefited (more influence) by the distance from organizational boundary while the boundary-
spanning workers were not. This means that employees form the technical core with contacts beyond their workgroup and workflow can acquire more influence.

Conclusion

“Overall, the results of this study provide strong support for viewing individual influence form a structural perspective” (pg. 534). The numerous significant variables suggest that there are several structural sources of influence. In other words, “being in the right place” matters.