Path Dependent Network Advantage: The Serial Closure Hypothesis

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Puzzle & Hypothesis
Individual Differences in Returns to Network Advantage

Discovery
Volatility Treated as Noise
Volatility Treated as Signal

Corroboration
Figure 1
Variable Returns to Advantage

Graph A is from Figure 2.3 showing achievement increasing with more access to structural holes in open networks. Circles are z-score residual achievement for 1,986 observations averaged within five-point intervals of network constraint in each of six management populations (analysts, bankers, and managers in Asia, Europe, and North America, see discussion of Figure 2.3 in Chapter 2; heteroscedasticity is negligible, $X^2 = 2.97, 1$ d.f., $P \sim .08$). Bold line is the vertical axis predicted by the natural logarithm of network constraint. Graph B shows the raw data averaged in Graph A. Vertical axis is wider to accommodate more variable achievement. Heteroscedasticity is high due to achievement differences between advantaged individuals ($X^2 = 269.5, 1$ d.f., $P < .001$), but the association between achievement and network advantage remains statistically significant when adjusted for heteroscedasticity (Huber-White, $t = -8.49$). Bold lines in graph B are hypothetical, distinguishing high-yield from low-yield network advantage.

A. Achievement Scores for People in Open Networks Are Higher than Peers on Average ($r = -.58, t = -6.78, n = 85$)

B. But Vary Widely between the Advantaged Individuals (overall $r = -.24$, $t = -9.98, n = 1,989$)
Bob Bob Bob Bob Bob
February April June August October December
Network Survey

Deb Deb Deb Deb Deb

NonRedundant
Contacts (thin solid line)

Network Density & Constraint (bold line is constraint)

Bob Is Always a Broker
Contacts

Bob Is Always a Broker
(Metrics oscillate through reversals)

Figure 5.
Broker Network Can Result from Always Being a Broker, or from Serial Closure
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Network Volatility — Noise or Signal?

Illustrating the privilege accorded stability in network analysis, here is Laumann & Pappi (1976:213) on community elites: "Despite differences in nuance associated with 'structure,' the root meaning refers to a persisting order or pattern of relationships among units of sociological analysis, be they individual actors, classes of actors, or behavioral patterns.”

Nadel (1957:9) is cited as precedent: "We identify the mutual ways of acting of individuals as 'relationships' only when the former exhibit some consistency and constancy, wince without these attributes they would merely be single or disjointed acts.”

Of course, implicit in Laumann & Pappi’s emphasis on stability is Nadel’s (1957:8) conceptual distinction between stable structures and variable parts: "structure indicates an ordered arrangement of parts, which can be treated as transposable, being relatively invariant, while the parts themselves are variable.”
Data for Volatility as Noise

Four annual panels of compensation and network data on 346 investment bankers employed by the study organization in each of the four panels.

Network data are from annual 360 evaluation process ($z_{ji} = 1$ if j cited i or i cited j as a colleague with whom citer had frequent and substantive business during previous year, 0 otherwise; summary colleague evaluation for banker i is average across colleagues j of $z_{ji}$ on 4-point scale).

There are also some control variables (banker’s job rank, colleague evaluation, years in organization, minority, works at headquarters).

Measures of network advantage:

Network eigenvector measures centrality/status

$$s_i = \sum_j p_{ji}s_j,$$

where $p_{ji}$ is proportion of i’s relations that are with j.

Network constraint measures lack of access to structural holes

$$c_i = \sum_j c_{ij},$$

where $c_{ji} = (p_{ij} + \sum_k p_{ik}p_{kj})^2,$ $k \neq i, j,$ and $p_{ij}$ is the proportion of i’s relations that are with j.
Figure 1.
Enduring Banker Relations Better Reveal Social Clusters

Legend: Color indicates banker job rank: top (gold), senior (gray), or other (white). Shape indicates location: US (circle) or elsewhere (square). Lines in sociogram A connect bankers linked by a citation in any of the four years. Lines in sociogram B connect bankers linked by a citation in all four years.
Table 2. Compensation Returns to Network Advantage

<table>
<thead>
<tr>
<th></th>
<th>All Years</th>
<th></th>
<th></th>
<th>Between Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>V</td>
</tr>
<tr>
<td>Network Status</td>
<td>.41 (.05)**</td>
<td>—</td>
<td>.47 (.05)**</td>
<td>.33 (.04)**</td>
</tr>
<tr>
<td>Network Constraint</td>
<td>—</td>
<td>-.31 (.07)**</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Job Rank 2</td>
<td>.20 (.08)*</td>
<td>.20 (.09)*</td>
<td>.20 (.08)*</td>
<td>.23 (.03)**</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>.51 (.09)**</td>
<td>—</td>
<td>.24 (.03)**</td>
</tr>
<tr>
<td>Job Rank 3</td>
<td>.48 (.09)**</td>
<td>.51 (.09)**</td>
<td>.50 (.08)**</td>
<td>.59 (.06)**</td>
</tr>
<tr>
<td>Job Rank 4</td>
<td>1.48 (.10)**</td>
<td>1.64 (.11)**</td>
<td>1.37 (.10)**</td>
<td>1.55 (.10)**</td>
</tr>
<tr>
<td></td>
<td>1.58 (.11)**</td>
<td>—</td>
<td>1.58 (.11)**</td>
<td>1.74 (.11)**</td>
</tr>
<tr>
<td>Colleague Evaluation</td>
<td>.17 (.04)**</td>
<td>.18 (.04)**</td>
<td>.13 (.04)**</td>
<td>.12 (.02)**</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>.62 (.06)**</td>
<td>—</td>
<td>.14 (.03)**</td>
</tr>
<tr>
<td>Years with the Organization</td>
<td>.004 (.01)</td>
<td>.008 (.01)</td>
<td>.001 (.01)</td>
<td>-0.03 (.01)</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>.006 (.01)</td>
<td>—</td>
<td>.002 (.01)</td>
</tr>
<tr>
<td>Minority (gender or race)</td>
<td>-.07 (.07)</td>
<td>-.08 (.08)</td>
<td>-.05 (.07)</td>
<td>-.07 (.04)</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>-.09 (.05)</td>
</tr>
<tr>
<td>US Headquarters</td>
<td>-.11 (.06)</td>
<td>-.06 (.06)</td>
<td>-.14 (.06) *</td>
<td>-.09 (.05)</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>-.07 (.06)</td>
<td>-.04 (.05)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-.91</td>
<td>.21</td>
<td>-.91</td>
<td>-.81</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>.78</td>
<td>—</td>
<td>.31</td>
</tr>
<tr>
<td>Multiple Correlation Squared</td>
<td>.71</td>
<td>.68</td>
<td>.74</td>
<td>.71</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>.70</td>
<td>—</td>
<td>.66</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>346</td>
<td>346</td>
<td>346</td>
<td>1038</td>
</tr>
</tbody>
</table>

NOTE — Unstandardized OLS regression coefficients are presented with standard errors in parentheses. Compensation is measured as a z-score. Network status is an eigenvector score normalized to the average banker. Network constraint is the log of constraint. See Appendix B for control variables, means, standard deviations, and correlations. Models I and II predict compensation summed across years from network indices computed from relations pooled over time (relation is 1 if it occurs in only one year, 2 if two years, etc.). Network status is correlated -.86 with log network constraint. Models III and IV predict annual compensation averaged across years from network indices computed for each year then averaged across years. Network status is again correlated -.86 with log network constraint. Models V and VI predict compensation next year from network indices this year (with standard errors adjusted for autocorrelation between repeated observations of the same bankers using the “cluster” option in STATA). * p < .05, ** p ≤ .001
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Network constraint measuring lack of access to structural holes ($c_i = \sum_j c_{ij}$, where $c_{ji} = (p_{ij} + \sum_k p_{ik} p_{kj})^2$, $k \neq i, j$ and $p_{ij}$ is the proportion of i’s relations that are with j).

Measures of network volatility:

Positive churn dummy (1 if middle third of percent change in contacts in 4 years)

Wide variation dummy (1 if above-median standard deviation in network score over time)

Trend up dummy (1 if positive slope on banker’s over time)

Negative trend dummy (1 if negative slope on banker’s over time)

Reversals dummy (1 if slope of change in banker’s scores reverses during the 4 years)
Reversal refers to change this year contradicted next year, as when banker status decreases this year after increasing last year (e.g., bankers C and D). No reversals means that banker status was stable from year to year (e.g., banker E), or changed in one direction (e.g., banker A’s increasing status).
Table 4.
Compensation Returns to Network Advantage and Volatility

<table>
<thead>
<tr>
<th>Volatility Level Adjustments</th>
<th>Network Status Predictions</th>
<th>Network Constraint Predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(at median network advantage)</td>
<td>III</td>
<td>VII</td>
</tr>
<tr>
<td>Positive Churn in Contacts</td>
<td>-.00 (.01)</td>
<td>-.00 (.06)</td>
</tr>
<tr>
<td>Wide Variation in Advantage</td>
<td>.07 (.08)</td>
<td>.13 (.18)</td>
</tr>
<tr>
<td>Positive Trend in Advantage</td>
<td>.02 (.08)</td>
<td>.07 (.10)</td>
</tr>
<tr>
<td>Negative Trend in Advantage</td>
<td>-.07 (.10)</td>
<td>-.00 (.08)</td>
</tr>
<tr>
<td>Reversal in Advantage</td>
<td>-.00 (.08)</td>
<td>-.00 (.06)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volatility Slope Adjustments</th>
<th>Network Status Predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(at low volatility)</td>
<td></td>
</tr>
<tr>
<td>Network Status</td>
<td>.47 (.05)**</td>
</tr>
<tr>
<td>Network Constraint</td>
<td>-.41 (.08)**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volatility Slope Adjustments</th>
<th>Network Constraint Predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Positive Churn)*(Network-Median)</td>
<td>-.02 (.16)</td>
</tr>
<tr>
<td>(Wide Variation)*(Network-Median)</td>
<td>.15 (.12)</td>
</tr>
<tr>
<td>(Positive Trend)*(Network-Median)</td>
<td>.13 (.18)</td>
</tr>
<tr>
<td>(Negative Trend)*(Network-Median)</td>
<td>.22 (.15)</td>
</tr>
<tr>
<td>(Reversal)*(Network-Median)</td>
<td>.38 (.14)**</td>
</tr>
</tbody>
</table>

Intercept       -.91       -.67       -.79       .78       .33       .33
R²              .74        .76        .76        .70        .71        .71

NOTE — OLS regression coefficients are presented with standard errors in parentheses. Z-score compensation, network status, and network constraint are average annual scores as in Models III and IV in Table 2. Means, standard deviations, and correlations for Models VII and VIII are given in Appendix B, Tables B2 and B3 respectively. All models include the seven Table 2 control variables for job rank, colleague evaluation, years with organization, minority, and US headquarters. Volatility variable “Positive Churn” equals one for bankers outside the shaded cells in Table 3 indicating stability traps. Level adjustments show change in compensation associated with the five binary volatility measures defined in the text. Slope adjustments are interaction terms between volatility variables and network advantage as a deviation from its median. * p < .05, ** p ≤ .01
Three Conclusions and an Inference

(1) Network volatility does not affect performance directly. Compensation is neither higher nor lower for bankers in volatile networks — holding constant level of network advantage and allowing for slope adjustments.

(2) Volatility has its effect by enhancing a person’s returns to level of network advantage. Adding volatility to the predictions did not strengthen the network effect. It disaggregated the effect into a portion due to level of advantage and a portion due to volatility. Just holding constant the corrosive effect of stability traps, the split is about equal between network advantage level versus volatility.

(3) The network volatility that protects against stability traps is a specific kind. It is not making new contacts in place of old. Churn should be moderate, about what is typical for the median person. It is not a matter of trend. Trend has no association with performance beyond level of network advantage. The variation associated with compensation is reversal: a pattern in which advantage is lost then regained, or gained then lost. Bankers who go through network reversals enjoy significantly higher returns to their level of network advantage. In fact, compensation has no association with level of network advantage for the bankers who failed to experience a reversal during the four years.

Our inference from the analysis is that a substantial portion of network advantage is path dependent — advantage is about level of advantage, but it is also about how one’s level of advantage developed. In contrast to the positive image of continuous access to structural holes, the “serial closure” hypothesis is that advantage depends on discontinuous access.
Figure 5.
Broker Network Can Result from Always Being a Broker, or from Serial Closure
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A. Achievement Scores for People in Open Networks Are Higher than Peers on Average ($r = -.58$, $t = -6.78$, $n = 85$)

B. But Vary Widely between the Advantaged Individuals (overall $r = -.24$, $t = -9.98$, $n = 1,989$)
Table 5. Returns to Brokerage Are Higher for Bankers Who Experienced Network Reversals

<table>
<thead>
<tr>
<th>Network Reversals</th>
<th>Access to Structural Holes</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High (Brokers)</td>
<td>Average</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Yes (banker reversals in status AND access to structural holes, n = 76)</td>
<td>1.11</td>
<td>-.16</td>
<td>-.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(25)</td>
<td>(27)</td>
<td>(24)</td>
<td></td>
</tr>
<tr>
<td>Probably (banker reversal in status OR access to structural holes, n = 143)</td>
<td>.34</td>
<td>-.13</td>
<td>-.11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(47)</td>
<td>(48)</td>
<td>(48)</td>
<td></td>
</tr>
<tr>
<td>No (no reversals, n = 127)</td>
<td>-.39</td>
<td>-.02</td>
<td>-.11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(39)</td>
<td>(41)</td>
<td>(47)</td>
<td></td>
</tr>
<tr>
<td>All Bankers</td>
<td>.26</td>
<td>-.10</td>
<td>-.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(111)</td>
<td>(116)</td>
<td>(119)</td>
<td></td>
</tr>
<tr>
<td>Probability No Difference Between the Rows (t-test)</td>
<td>4.38</td>
<td>0.08</td>
<td>-0.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P &lt; .001</td>
<td>P ~ .94</td>
<td>P ~ .40</td>
<td></td>
</tr>
</tbody>
</table>

NOTE — Rows distinguish bankers by reversals in network status and constraint using the two dummy “reversal” variables in Table 4. Columns distinguish bankers by network constraint. The third of bankers with the lowest average constraint scores over time are in the “High” access column to the left. The third with the highest average constraint scores are in the “Low” access column to the right. Cell entries are mean z-score annual compensation adjusted for the seven control variables in Table 2 (Model IV). Number of bankers is in parentheses. Test statistics are for differences between the three row compensation means in a column, holding constant the seven control variables in Table 2 (log network constraint in Model IV in Table 2 is replaced with a linear comparison between the rows).
Table 6. And Reputation Builds Despite the Disruptions from Network Reversals

<table>
<thead>
<tr>
<th>Network Reversals</th>
<th>Initial Colleague Evaluation</th>
<th>Reputation Persistence, This Year to Next Year</th>
<th>Closure Correlation With Persistence</th>
<th>Network Status in the Last Two Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (banker reversals in status AND access to structural holes, n = 76)</td>
<td>3.03</td>
<td>.60</td>
<td>.61</td>
<td>1.24</td>
</tr>
<tr>
<td>Probably (banker reversal in status OR access to structural holes, n = 143)</td>
<td>3.00</td>
<td>.58</td>
<td>.48</td>
<td>1.02</td>
</tr>
<tr>
<td>No (no reversals, n = 127)</td>
<td>3.01</td>
<td>.54</td>
<td>.43</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Probability No Difference Between the Rows (t-test): 0.25, P ~ .81; 1.37, P ~ .17; 1.89, P ~ .06; 3.51, P ~ .001

NOTE — Rows distinguish bankers by reversals in network status and constraint using the two dummy “reversal” variables in Table 4. Colleague evaluation is the mean evaluation of a banker in the first of the annual panels by the other 345 continuing employees in the bonus pool (evaluations vary from 1 to 4). Reputation persistence is the correlation between the mean evaluations of a banker this year and next, across a dozen colleagues with networks similar to the banker. Next column is the correlation between the persistence correlation and a measure of closure around a banker’s contacts (more closure, more persistence, see Figure 6). Status is an annual network eigenvector score normalized to the average for the year, then averaged across the last two of the annual panels. The t-tests are for a linear contrast across the rows predicting the column variable while holding constant the three job rank variables in Table 2.
Figure 6.
Reputation Dependence on Closed Networks

Reputation Stability (subsample correlation this year to next)

Network Closure Around Contacts
(mean number of third parties to relations between contacts and their contacts)

\[ Y = -0.15 + 0.36 \ln(X+1), \]
\[ R^2 = 0.93 \]
Appendix Materials
I do not argue in Structural Holes that holes have to be stable to provide their advantage.

I used Google Books to check for the words "stable" and "stability" in Structural Holes. I found 24 instances (putting aside two cited articles, one with "stable" in the title, and the other with "stability" in the title):

Two of the 24 instances concerned effect stability. Manager network effects were stable across alternative network metrics (p. 166), and network composition is stable across the sample managers (p. 125) in that most managers cited — a boss, 2 friends or family, 2 subordinates, 3 dotted line contacts, and 5 colleagues beyond solid and dotted lines.

Two instances concerned causal order in that level of network constraint on a manager was assumed stable back to his or her last promotion (pp. 121 & 174). The assumption is followed by a note on instability: "This is not to say that individual contacts continue over time. The people relevant for one project can be completely different for another project. But the social structure the manager fosters in his or her network can be quite stable." The assumption of stable network metrics is needed to predict age at promotion from current network. It is clearly a heroic assumption given the results to be presented here, but it is not an assumption that structural holes have to be stable to provide their advantage.

The other 17 instances of stable or stability, the majority of the 24, were in the discussion of input-output tables, which are based on production technology, not personal preference, and had been shown in articles preceding Structural Holes to be stable through years preceding the analysis in the book.
### Table 1.

**Network Advantage Is Autocorrelated in Simplex Structure**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Status in Year 1</strong></td>
<td>1.00</td>
<td>1.06</td>
</tr>
<tr>
<td><strong>Status in Year 2</strong></td>
<td>1.00</td>
<td>0.83</td>
</tr>
<tr>
<td><strong>Status in Year 3</strong></td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Status in Year 4</strong></td>
<td>1.00</td>
<td>0.74</td>
</tr>
<tr>
<td><strong>Status All Years</strong></td>
<td>1.00</td>
<td>0.70</td>
</tr>
<tr>
<td><strong>Status Within Years</strong></td>
<td>1.00</td>
<td>0.79</td>
</tr>
<tr>
<td><strong>Constraint in Year 1</strong></td>
<td>3.38</td>
<td>0.79</td>
</tr>
<tr>
<td><strong>Constraint in Year 2</strong></td>
<td>3.26</td>
<td>0.57</td>
</tr>
<tr>
<td><strong>Constraint in Year 3</strong></td>
<td>3.40</td>
<td>0.64</td>
</tr>
<tr>
<td><strong>Constraint in Year 4</strong></td>
<td>3.23</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>Constraint All Years</strong></td>
<td>2.59</td>
<td>0.56</td>
</tr>
<tr>
<td><strong>Constraint Within Years</strong></td>
<td>3.32</td>
<td>0.53</td>
</tr>
</tbody>
</table>

**NOTE** — Statistics are computed across 346 bankers. Status is a network eigenvector score normalized to the average score, so 1.0 is the average. Constraint is the log of network constraint on a zero to 100 scale. Status and constraint scores “All Years” are computed from relations pooled over time (relation is 1 if it occurs in one year, 2 if it occurs in two years, etc.). Status and constraint scores “Within Years” are computed within each year then averaged across the four years.
Figure 5. Illustrative Churn and Variation

<table>
<thead>
<tr>
<th>Network Metrics:</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Churn</strong></td>
<td>0%</td>
<td>17%</td>
<td>17%</td>
<td>17%</td>
<td>75%</td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td>1.69</td>
<td>.12</td>
<td>2.92</td>
<td>3.09</td>
<td>2.54</td>
</tr>
<tr>
<td>Year One</td>
<td>2.19</td>
<td>2.88</td>
<td>.68</td>
<td>1.16</td>
<td>1.86</td>
</tr>
<tr>
<td>Year Two</td>
<td>.50</td>
<td>1.04</td>
<td>-2.24</td>
<td>-1.93</td>
<td>-.68</td>
</tr>
<tr>
<td><strong>Constraint</strong></td>
<td>25.0</td>
<td>20.0</td>
<td>16.7</td>
<td>16.7</td>
<td>33.3</td>
</tr>
<tr>
<td>Year One</td>
<td>25.0</td>
<td>16.7</td>
<td>20.0</td>
<td>20.0</td>
<td>50.0</td>
</tr>
<tr>
<td>Year Two</td>
<td>0.0</td>
<td>-3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>16.7</td>
</tr>
</tbody>
</table>

Legend: Shape indicates job rank: CEO (polygon), senior (square), or other (circle). Lines indicate substantial work contact.

Article Abstract (abbreviated): Active centres and hot spots of proteins have a paramount importance in enzyme action, protein-complex formation, and drug design. Recently, several publications successfully applied the analysis of residue networks to predict active centres in proteins. . . . Using analogy, I propose that existing findings and methodology already enable us to detect active centres in cells and can be expanded to social networks and ecosystems. Members of these active centres are termed here as ‘creative elements’ of their respective networks, which can help them to survive unprecedented, novel challenges and play a key part in the development, survival, and evolvability of complex systems.

Legend to figure 2 (right): Creative elements. The figure illustrates the integrative network position of creative elements integrating network communication, performing a partially random sampling of the network and connecting distant network modules. Creative elements often have transient, weak links leading to hubs. Creative elements (A and A') and hubs (b) are marked with red and green circles, respectively. Solid lines denote strong links, whereas dotted lines show weak, transient links. It is of key importance that the figure is a snapshot only and that the position of creative elements in real-world, dynamic networks will change to a similarly integrative position elsewhere in the network at the very next moment. This is illustrated by the jump of the creative element from position A to A'.
Figure 2. Performance Correlation with Network Advantage across Levels of Network Churn and Variation

These dots contain bankers 1 to 15 in the churn rank order.
### Table 3.
**Compensation Returns to Network Advantage by Categories of Network Volatility (stability traps shaded)**

| Network Status Predictions | Variation in Banker’s Annual Status Scores |  |  
|-----------------------------|------------------------------------------|---|---
| Churn in Banker’s Network   | Low SD (≤ .30)                            | High SD (> .30) |  
| Low (≤ 85%)                 | .23 (.15) [57]                            | .73 (.18)**[53] |  
| Moderate                    | .45 (.10)**[62]                            | .50 (.15)*[62] |  
| High (> 95%)                | -.00 (.11) [52]                            | .41 (.12)**[60] |  
| Network Constraint Predictions | Variation in Banker’s Annual Log Constraint Scores |  |  
| Churn in Banker’s Network   | Low SD (≤ .28)                            | High SD (> .28) |  
| Low (≤ 85%)                 | -.36 (.27) [55]                            | -.80 (.23)**[55] |  
| Moderate                    | -.93 (.34)*[73]                            | -.60 (.16)**[75] |  
| High (> 95%)                | -.00 (.11) [52]                            | .11 (.13) [45] |  
|                               |                                        | -.24 (.12)*[67] |  

**NOTE** — Each cell contains, for a combination of churn (% contact change) and variation (advantage standard deviation over time), the unstandardized regression coefficient predicting average annual z-score compensation from average annual network status in Model III (left) or average annual log network constraint in Model IV (right). The corresponding coefficients in Table 2 are .47 for status and -.41 for network constraint. Standard errors are given in parentheses, number of observations in brackets. Network variation (columns) distinguishes low versus high at the median. Moderate churn is anchored on the median of 90%. * p < .05, ** p ≤ .001
**Figure 3.**

Returns to Status for Bankers at Low Versus High Network Volatility

Y is z-score banker compensation.

Sm and logCm are median values of network status and log network constraint.

V is a dummy variable equal to 0 if banker is in a Table 3 stability trap (black dots in graph).

$X_k$ is the $k^{th}$ control variable in Table 2.

\[
Y = -0.77 + 0.04(V) + [0.21 + 0.30V](S - Sm) + \sum b_k X_k + e, \quad R^2 = 0.75 \\
(0.07) \quad (0.12) \quad (0.13)
\]

\[
Y = 0.30 - 0.03(V) - [0.25 + 0.20V](\log C - \log Cm) + \sum b_k X_k + e, \quad R^2 = 0.70 \\
(0.07) \quad (0.12) \quad (0.13)
\]
**Table B1.**  
Means, Standard Deviations, and Correlations for Table 2.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Z-Score Compensation</td>
<td>—</td>
<td>.67</td>
</tr>
<tr>
<td></td>
<td>.74</td>
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</tr>
<tr>
<td></td>
<td>.22</td>
<td>.42</td>
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<td>-.21</td>
<td>.01</td>
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<tr>
<td></td>
<td>0.00</td>
<td>1.00</td>
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<tr>
<td>Network Status</td>
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<tr>
<td></td>
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<td>.55</td>
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<tr>
<td></td>
<td>.16</td>
<td>.43</td>
</tr>
<tr>
<td></td>
<td>-.15</td>
<td>.12</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>.96</td>
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<tr>
<td>Network Constraint</td>
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<td>-.86</td>
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<tr>
<td></td>
<td>—</td>
<td>-.52</td>
</tr>
<tr>
<td></td>
<td>-.12</td>
<td>-.39</td>
</tr>
<tr>
<td></td>
<td>.13</td>
<td>-.06</td>
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<tr>
<td></td>
<td>3.35</td>
<td>.67</td>
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<tr>
<td>Job Rank</td>
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<td>—</td>
</tr>
<tr>
<td></td>
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<td>.02</td>
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<td></td>
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<td>1.16</td>
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<td>Colleague Evaluation</td>
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<tr>
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<td>.08</td>
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<td></td>
<td>.48</td>
<td>-.21</td>
</tr>
<tr>
<td></td>
<td>.20</td>
<td>.87</td>
</tr>
<tr>
<td>Years with Organization</td>
<td>.43</td>
<td>.44</td>
</tr>
<tr>
<td></td>
<td>-.42</td>
<td>.46</td>
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<td></td>
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<td>—</td>
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<td></td>
<td>.05</td>
<td>-.11</td>
</tr>
<tr>
<td></td>
<td>6.05</td>
<td>5.41</td>
</tr>
<tr>
<td>Minority (gender or race)</td>
<td>-.21</td>
<td>-.16</td>
</tr>
<tr>
<td></td>
<td>.16</td>
<td>-.21</td>
</tr>
<tr>
<td></td>
<td>-.13</td>
<td>-.03</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>-.03</td>
</tr>
<tr>
<td></td>
<td>.23</td>
<td>.42</td>
</tr>
<tr>
<td>US Headquarters</td>
<td>.01</td>
<td>.15</td>
</tr>
<tr>
<td></td>
<td>-.08</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td>.08</td>
<td>.09</td>
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<td>—</td>
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<td></td>
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<td>Mean</td>
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<td>1.00</td>
</tr>
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<td>Standard Deviation</td>
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<td>.79</td>
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<td></td>
<td>.53</td>
<td>1.15</td>
</tr>
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<td></td>
<td>.81</td>
<td>5.35</td>
</tr>
<tr>
<td></td>
<td>.42</td>
<td>.49</td>
</tr>
</tbody>
</table>

**NOTE** — Statistics below the diagonal are computed from scores averaged to describe the four-year period (346 bankers in Table 2 models except Models V and VI). Statistics above the diagonal are computed from three repeated observations of annual scores this year and compensation next year (1038 observations for Models V and VI in Table 2). Compensation is dollars of annual salary and bonus measured as an annual z-score, averaged across years for the below diagonal correlations. Status is a network eigenvector score normalized to the average score this year, then averaged across years for the below diagonal (Model III in Table 2). Constraint is the log of network constraint this year, averaged across years for the below diagonal (Model IV in Table 2). “Job rank” is a four-level variable this year, defined below the diagonal as the job rank in which a banker spent most of the four-year period. “Job rank” is entered as three dummy variables in Table 2. “Colleague Evaluation” is the average annual evaluation of a banker by the other 345 continuing employees in the bonus pool this year, converted to a z-score for this year, and averaged across years for the below diagonal. “Years with the Organization” is above the diagonal years since the banker was hired. Below the diagonal it is years as of the end of the second year in the four-year period. “US Headquarters” refers to bankers who spent more of the four-year period at the US headquarters office than at any other location.
<table>
<thead>
<tr>
<th>Volatility Level Adjustments</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Churn &amp; Variation</td>
<td>—</td>
<td>.68</td>
</tr>
<tr>
<td>Positive Trend</td>
<td>-.12</td>
<td>.21</td>
</tr>
<tr>
<td>Negative Trend</td>
<td>.05</td>
<td>.13</td>
</tr>
<tr>
<td>Reversal</td>
<td>.29</td>
<td>.40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volatility Slope Adjustments</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Positive Churn &amp; Variation)*(Status-.78)</td>
<td>.27</td>
<td>.28</td>
</tr>
<tr>
<td>(Positive Trend)*(Status-.78)</td>
<td>.20</td>
<td>-.03</td>
</tr>
<tr>
<td>(Negative Trend)*(Status-.78)</td>
<td>.16</td>
<td>.05</td>
</tr>
<tr>
<td>(Reversal)*(Status-.78)</td>
<td>.23</td>
<td>.22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Variables</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z-Score Compensation</td>
<td>.29</td>
<td>.00</td>
</tr>
<tr>
<td>Network Status</td>
<td>.36</td>
<td>1.00</td>
</tr>
<tr>
<td>Job Rank</td>
<td>.24</td>
<td>2.51</td>
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<tr>
<td>Colleague Evaluation</td>
<td>.13</td>
<td>.00</td>
</tr>
<tr>
<td>Years with Organization</td>
<td>.10</td>
<td>6.05</td>
</tr>
<tr>
<td>Minority (gender or race)</td>
<td>-.01</td>
<td>.23</td>
</tr>
<tr>
<td>US Headquarters</td>
<td>.13</td>
<td>.59</td>
</tr>
</tbody>
</table>

NOTE — These are zero-order statistics for Model VII in Table 4 except the four categories of job rank are listed here as a single variable instead of the three dummy variables used to completely hold job rank constant in Model VII (job rank = 1, 2, 3, 4). High volatility is binary, as explained in the text. Interaction terms are binary volatility multiplied by network status as a deviation from its median level (.78). Correlations among the “Other Variables” are in the lower diagonal of Table B1.
### TABLE B3. Means, Standard Deviations, and Correlations for Network Constraint Volatility in Table 4.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td><strong>Volatility Level Adjustments</strong></td>
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<td></td>
</tr>
<tr>
<td>Positive Churn &amp; Variation</td>
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<td>.71</td>
</tr>
<tr>
<td>Positive Trend</td>
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<td>.10</td>
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<tr>
<td>Negative Trend</td>
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<td>.13</td>
</tr>
<tr>
<td>Reversal</td>
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<td>.45</td>
</tr>
<tr>
<td><strong>Volatility Slope Adjustments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Positive Churn &amp; Variation)*(Constraint-3.3)</td>
<td>.09</td>
<td>-.09</td>
</tr>
<tr>
<td>(Positive Trend)*(Constraint-3.3)</td>
<td>.09</td>
<td>-.33</td>
</tr>
<tr>
<td>(Negative Trend)*(Constraint-3.3)</td>
<td>.13</td>
<td>-.03</td>
</tr>
<tr>
<td>(Reversal)*(Constraint-3.3)</td>
<td>.15</td>
<td>-.04</td>
</tr>
<tr>
<td><strong>Other Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z-Score Compensation</td>
<td>-.11</td>
<td>.06</td>
</tr>
<tr>
<td>Log Network Constraint</td>
<td>.21</td>
<td>-.13</td>
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<tr>
<td>Job Rank</td>
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<td>.07</td>
</tr>
<tr>
<td>Colleague Evaluation</td>
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<td>-.02</td>
</tr>
<tr>
<td>Years with Organization</td>
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<td>.18</td>
</tr>
<tr>
<td>Minority (gender or race)</td>
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<td>-.05</td>
</tr>
<tr>
<td>US Headquarters</td>
<td>.13</td>
<td>.02</td>
</tr>
</tbody>
</table>

NOTE — These are zero-order statistics for Model VIII in Table 4 except the four categories of job rank are listed here as a single variable instead of the three dummy variables used to completely hold job rank constant in Model VIII (job rank = 1, 2, 3, 4). High volatility is binary, as explained in the text. Interaction terms are binary volatility multiplied by log network constraint as a deviation from its median level (3.30). Correlations among the “Other Variables” are in the lower diagonal of Table B1.
Virtual World Opportunity: Network Endogeneity

Network activity is sometimes continuous, but it is more often clustered — as illustrated in the histograms of mentoring by two people.

Gaps between activity clusters are a lens on time order in network endogeneity (but not mutual causes).

<table>
<thead>
<tr>
<th>Maximum Interval between Activities Divided by Average Interval:</th>
<th>Average Ratio</th>
<th>Number of Avatars</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 or less</td>
<td>1.28</td>
<td>2,071 (17%)</td>
</tr>
<tr>
<td>More than 2</td>
<td>4.73</td>
<td>2,535 (21%)</td>
</tr>
<tr>
<td>More than 10</td>
<td>28.51</td>
<td>2,801 (24%)</td>
</tr>
<tr>
<td>More than 50</td>
<td>72.29</td>
<td>2,112 (18%)</td>
</tr>
<tr>
<td>More than 100</td>
<td>224.78</td>
<td>2,330 (20%)</td>
</tr>
</tbody>
</table>
Figure 1. Access to Structural Holes
(networks from Vedres and Stark, 2010:1157)

<table>
<thead>
<tr>
<th>Kind of Network</th>
<th>Contacts</th>
<th>Holes (betweenness)</th>
<th>Non-Redundant Contacts</th>
<th>Network Density</th>
<th>Network Hierarchy</th>
<th>Network Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broker (1)</td>
<td>2</td>
<td>1</td>
<td>2.0</td>
<td>0.0</td>
<td>0.0</td>
<td>50.0</td>
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<tr>
<td>Broker (2, 6)</td>
<td>4</td>
<td>3</td>
<td>2.5</td>
<td>0.5</td>
<td>4.7</td>
<td>58.3</td>
</tr>
<tr>
<td>Closed (3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 15, 16)</td>
<td>3</td>
<td>0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.0</td>
<td>92.6</td>
</tr>
<tr>
<td>Broker (10)</td>
<td>6</td>
<td>9</td>
<td>4.0</td>
<td>0.4</td>
<td>0.0</td>
<td>46.3</td>
</tr>
</tbody>
</table>
Benefiting from Network Advantage Is Contingent in Known Ways on the Situation and Your Behavior

- Not all bridges are valuable: Brokers play against the risk of productive accident.
- Bridges can be difficult regardless of value: Active versus passive structural holes.
- Valuable bridges are not equally valuable: Returns to brokerage are higher for more unique work.
- Bridges require structural holes: Don’t eliminate holes so much as manage them.
- Value can lie in different perspectives on information: Framing can be more important than content.
- Collateral brokerage: Don’t be greedy. Collateral brokerage builds the local economy.
- Trust and reputation can be critical: Are you trusted by the people you are trying to bridge? (Session 3)
- Trust and reputation can be critical: How you build the network affects the advantage it provides. (Session 5)
- In sum, individuals differ greatly in their returns to network brokerage.

Sociogram of Directors in Chicago Index Companies — Dots in the sociogram are the 1,380 Chicago directors in S&P 1500 firms, 1999-2003. Gold indicates a member of Chicago's Commercial Club (concentrated in the center, 13.2 t-test). Lines indicate directors connected through an interlocking directorate between Chicago companies or by sitting on a company board together outside Chicago. Isolate dots are the 818 people who sit on one Chicago board or one Chicago board plus outside boards containing no other Chicago elites.
Network Brokers Tend To Be the Leaders
Constraint and status are computed from work discussion networks around twelve hundred managers in four organizations.

Figure 2.4 in Burt, "Network structure of advantage" (2013 manuscript)
Bavelas-Leavitt Group Structures and Metrics

The four networks are from the Bavelas-Leavitt experiments on leadership in task groups. The WHEEL is a traditional bureaucracy in which C is in charge. The other three networks involve distributed leadership (all five people in the CIRCLE; B, C, and D in the CHAIN; C and D in the Y-NETWORK). More distributed leadership is associated with more messages (M), slower task completion, and greater enjoyment (E). Speed, messages, and enjoyment scores are from Leavitt (1951). Number of contacts (N) and network constraint (NC) are computed from binary ties in the sociograms (number of contacts equals number of non-redundant contacts in these structures).

Figure 2.5 in Burt, "Network structure of advantage" (2013 manuscript)
A. Network brokers tend to distribute answers, people in moderately constrained positions tend to be conduits for informational messages.

Data are from Leavitt (1949: Table 30, following page 62).

B. Network brokers are least happy initially, but eventually become the most pleased with the experience.

Data are from Leavitt (1949: Table 29, pages 60-61; "How did you like your job in the group?").

C. The final outcome, by the end of the experiment, is that network brokers are most likely to be recognized as the unofficial group leader.

Data are from Leavitt (1949: Table 8, page 38; "Did your group have a leader? If so, who?").

Figure 2.6 in Burt, "Network structure of advantage" (2013 manuscript)
Despite a high average rate of network decay (which implies volatile reputations because so much of evaluation variance is in the pair of people connected rather than either individual, see Appendix VI), reputations persist from one year to the next.

![Figure 6.3 in Neighbor Networks](image-url)

- Bankers ($r = .61$, $t = 13.16$)
- Analysts ($r = .55$, $t = 9.78$)

Reputation this Year
(average evaluation by colleagues)

Reputation next Year
(average evaluation by colleagues)
Closure Is Essential to Reputation Stability.
Positive and Negative Reputations Quickly Stabilize.
Implications for Building Reputation?

See Appendix V on third-party ties as a network-closure metric. See Appendix VII for detail separating positive versus negative embedding and analysis versus bankers. See Appendix VIII on groupthink and unlearning.
Essential Closure Is Around Contacts, Maintaining the Reputations of Brokers and People in Closed Networks

Vertical axis is same as on page 19. Horizontal axis is average number of third party connections in the networks around banker's contacts (rounded to nearest whole number). Brokers are bankers with below-median network constraint this year. Regression lines in graph go through averages. Regression equations estimated from 894 year-to-year banker transitions.

Figure 2.12 in Burt, "Network Structure of Advantage" (2013 manuscript)