Brokerage: The Network Structure of Competitive Advantage

For text on this session, see Chapters 1 to 4 in *Brokerage and Closure* (including adjunct bits from *Neighbor Networks*).

Appendices:

I. Example Network Questionnaire for a Web Survey (from 2010 *Neighbor Networks*, 2017 *Management and Organization Review*)

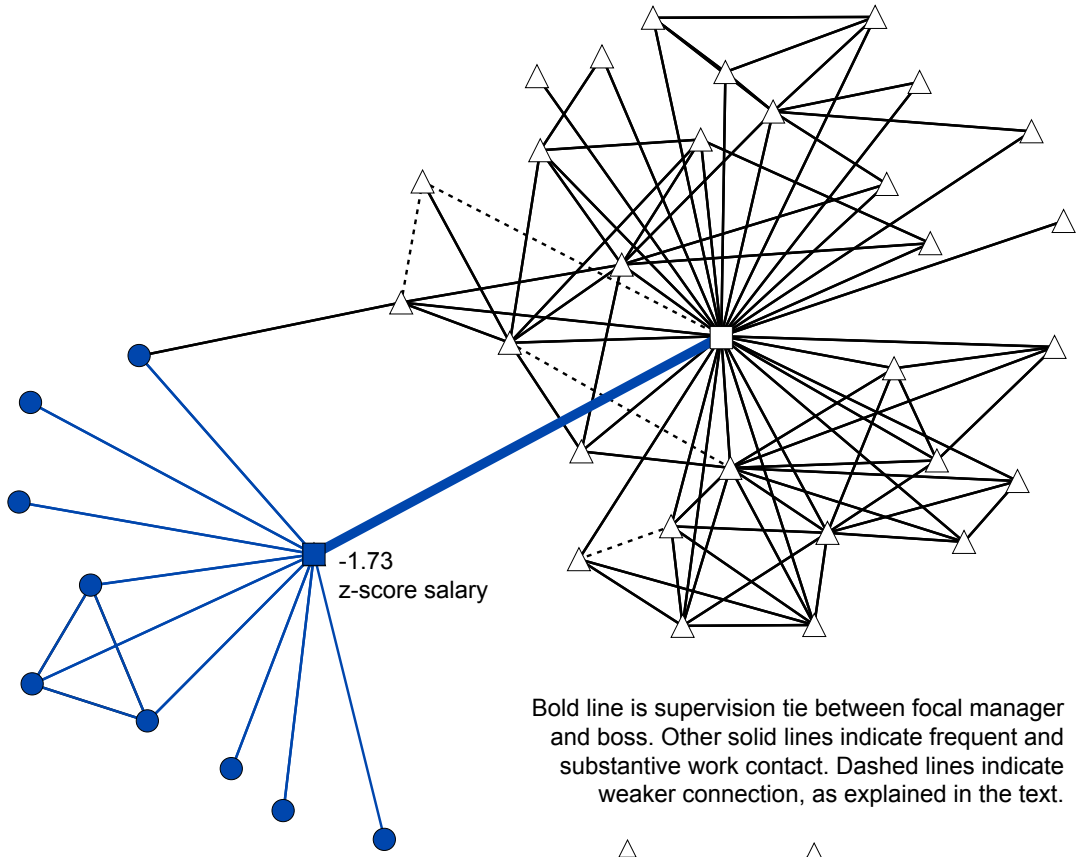
II. Measuring Access to Structural Holes (from 1992, *Structural Holes*, 2010 *Neighbor Networks*)

III. Quick Metric Regression Coefficients for log Network Constraint

Human Capital
(warning: "fundamental attribution error")

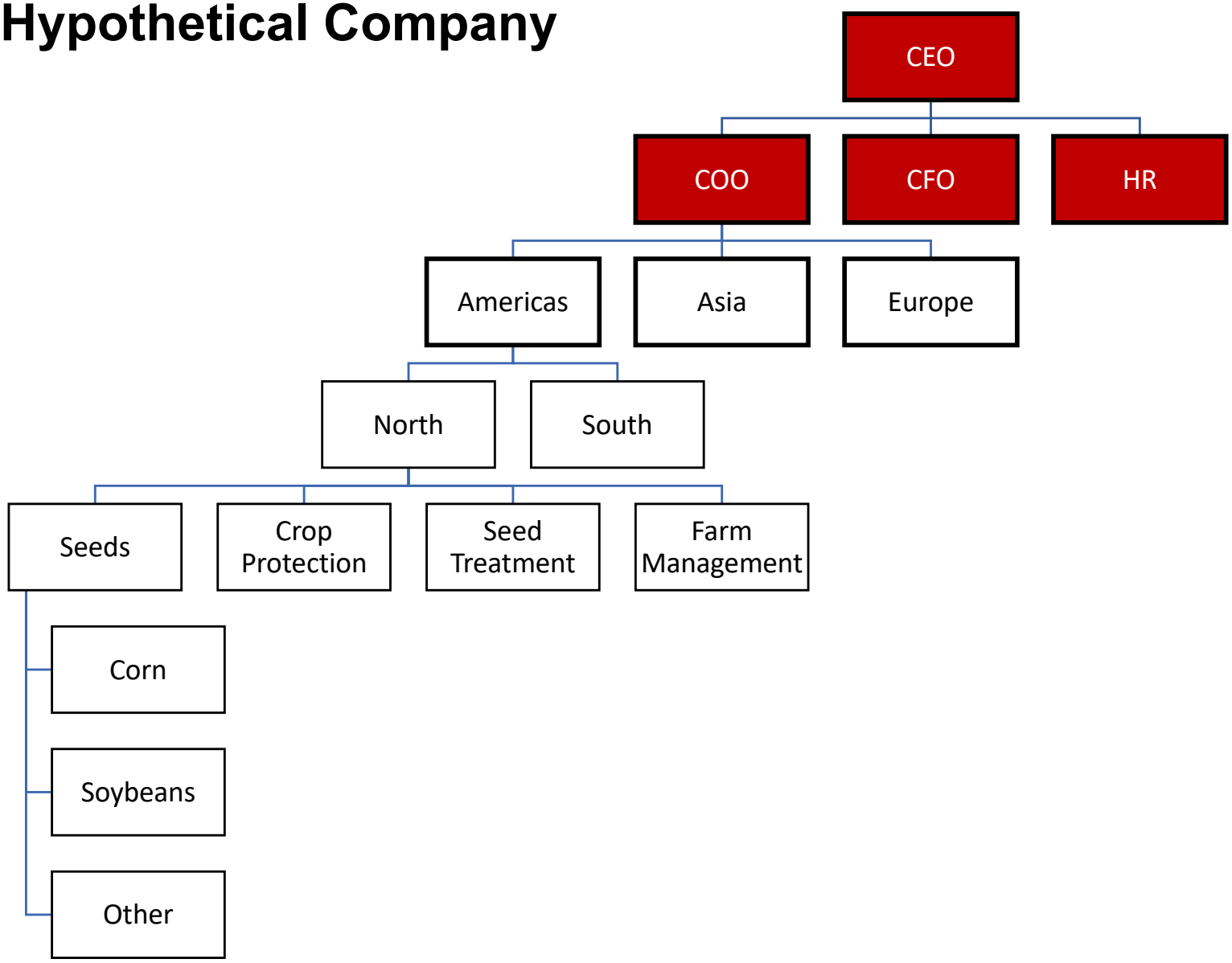
and

Social Capital
(a.k.a. "network advantage")

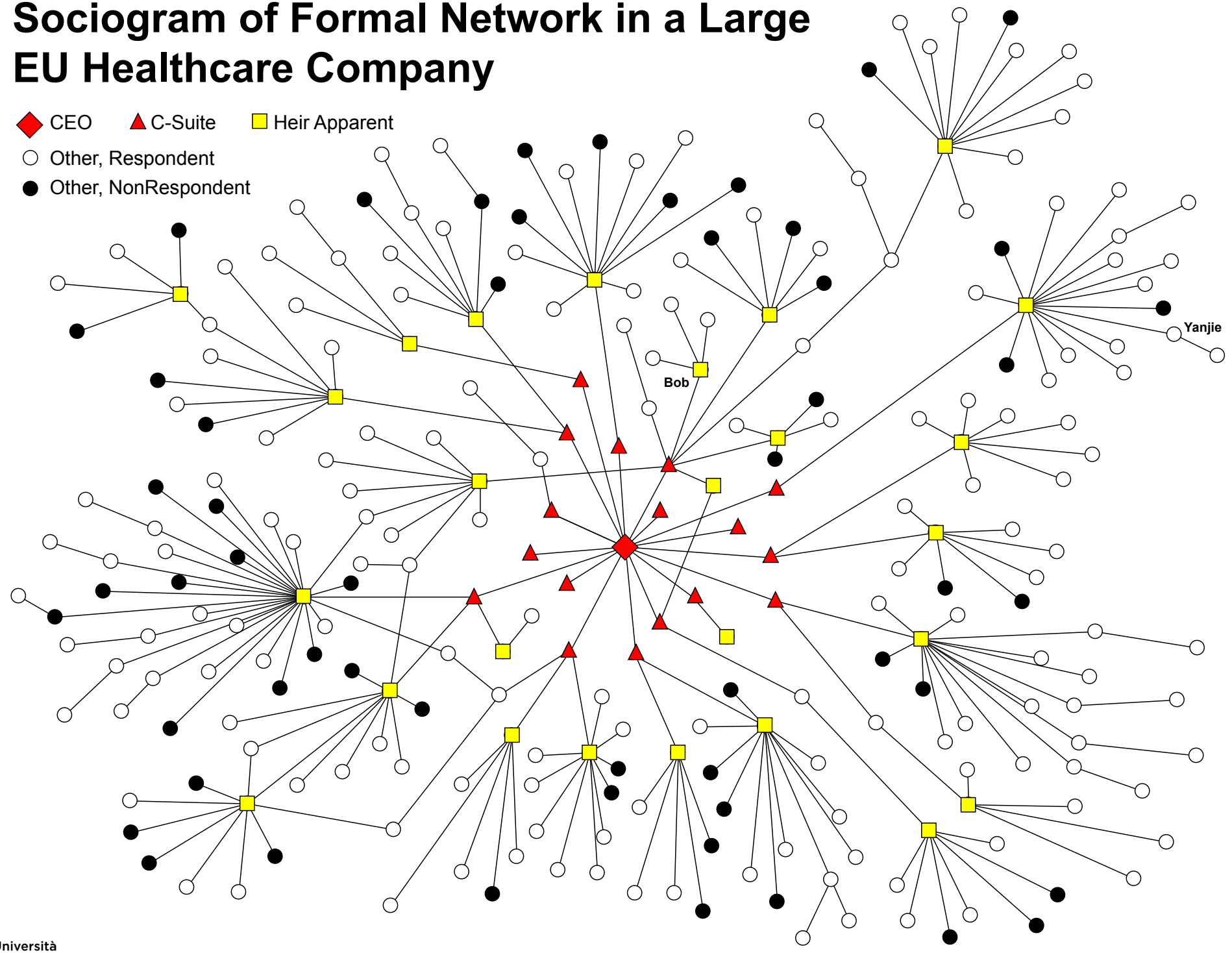


Graphic is from Figures 1 and 2 in Burt and Wang (2022, *Academy of Management Journal*, "Bridge supervision: Correlates of a boss on the far side of a structural hole."

This is Generic Organization Chart Showing the Formal Network in a Hypothetical Company



Sociogram of Formal Network in a Large EU Healthcare Company



Social Network at the Top of the Company

Lines indicate frequent and substantive work discussion; heavy lines especially close relationships.

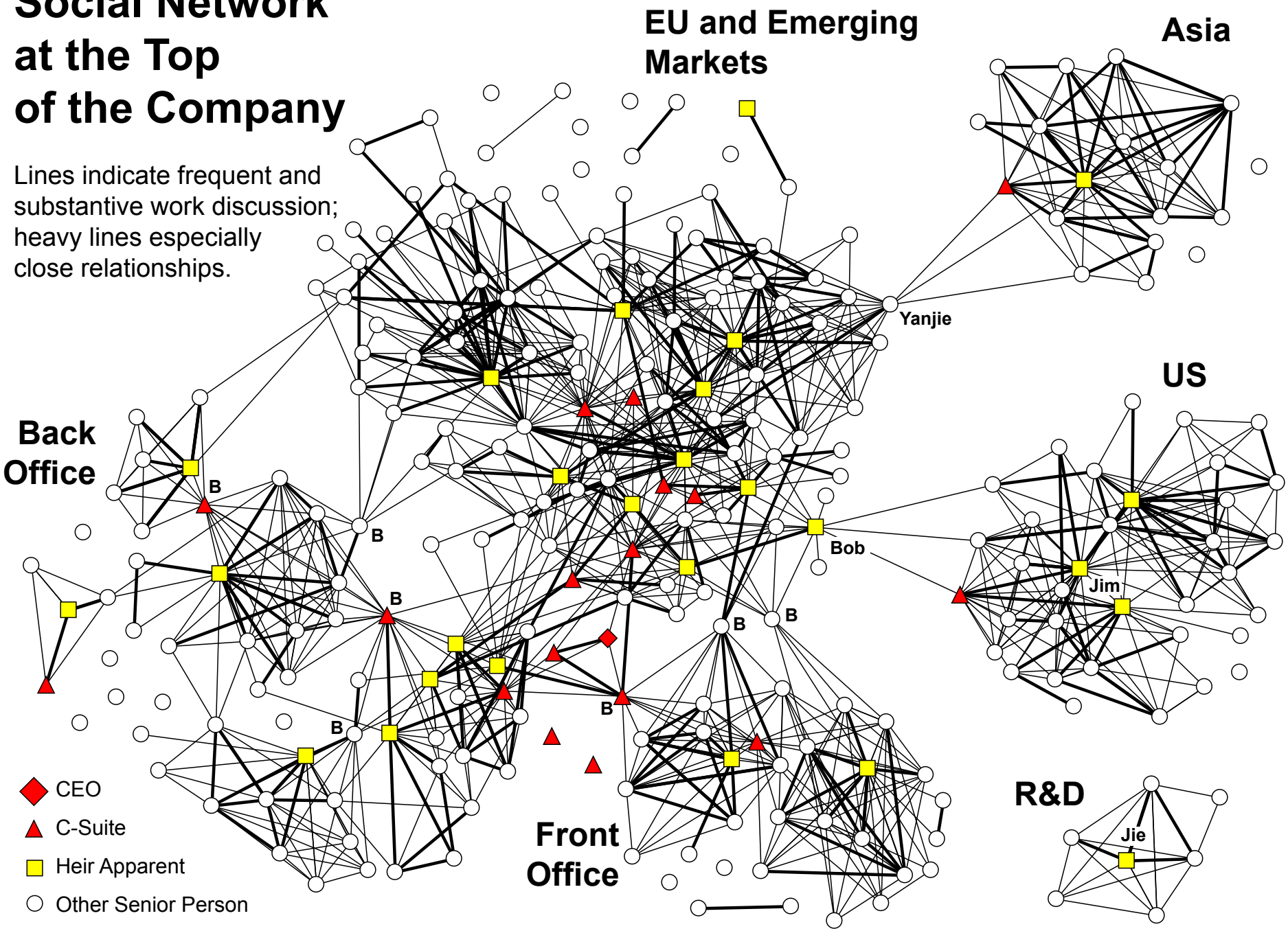
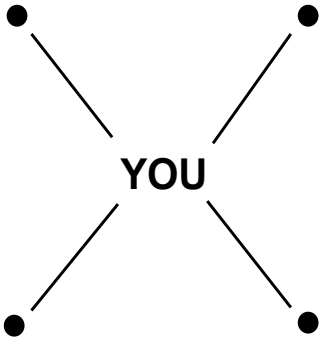
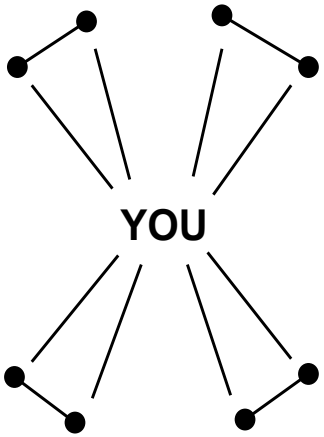


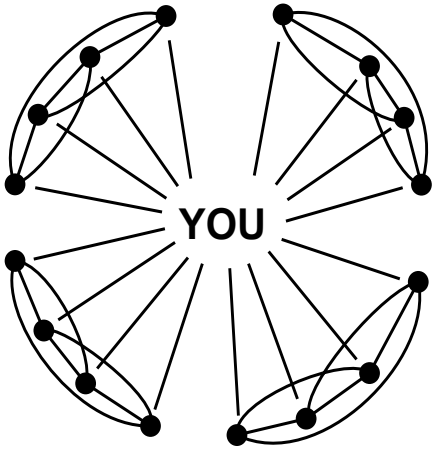
Figure 2 in Burt, "Network disadvantaged entrepreneurs" (*Entrepreneurship Theory & Practice*, 2019)



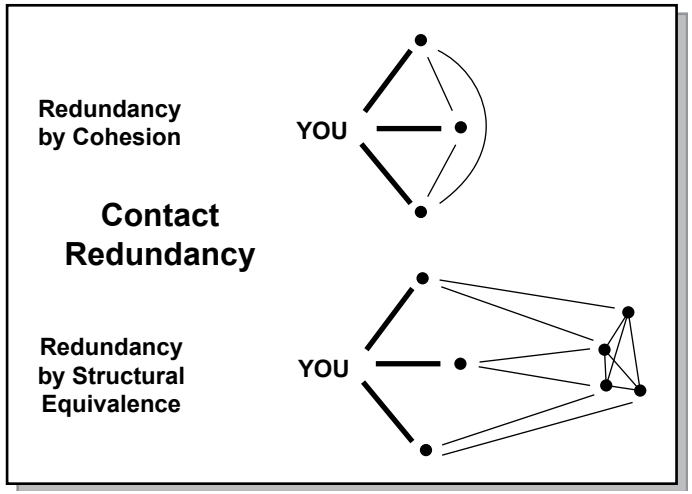
Network A



Network B



Network C



Network & Information

Contacts as Source vs. Portal

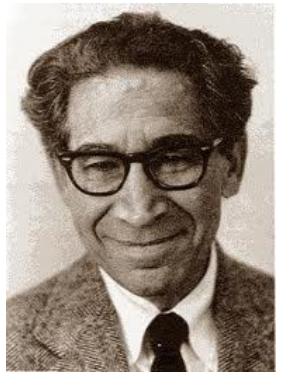
from Figures 1.1 and 1.3 in Burt (1992, *Structural Holes*) and Figure 1.2 in *Brokerage and Closure*

Long History in Social Science
Network Structure Maps the Distribution of Information

Paul Lazarsfeld 1901-1976

Bob Merton 1910-2003

Solomon Asch 1907-1996



Leon Festinger 1919-1989

Stanley Schachter 1922-1997

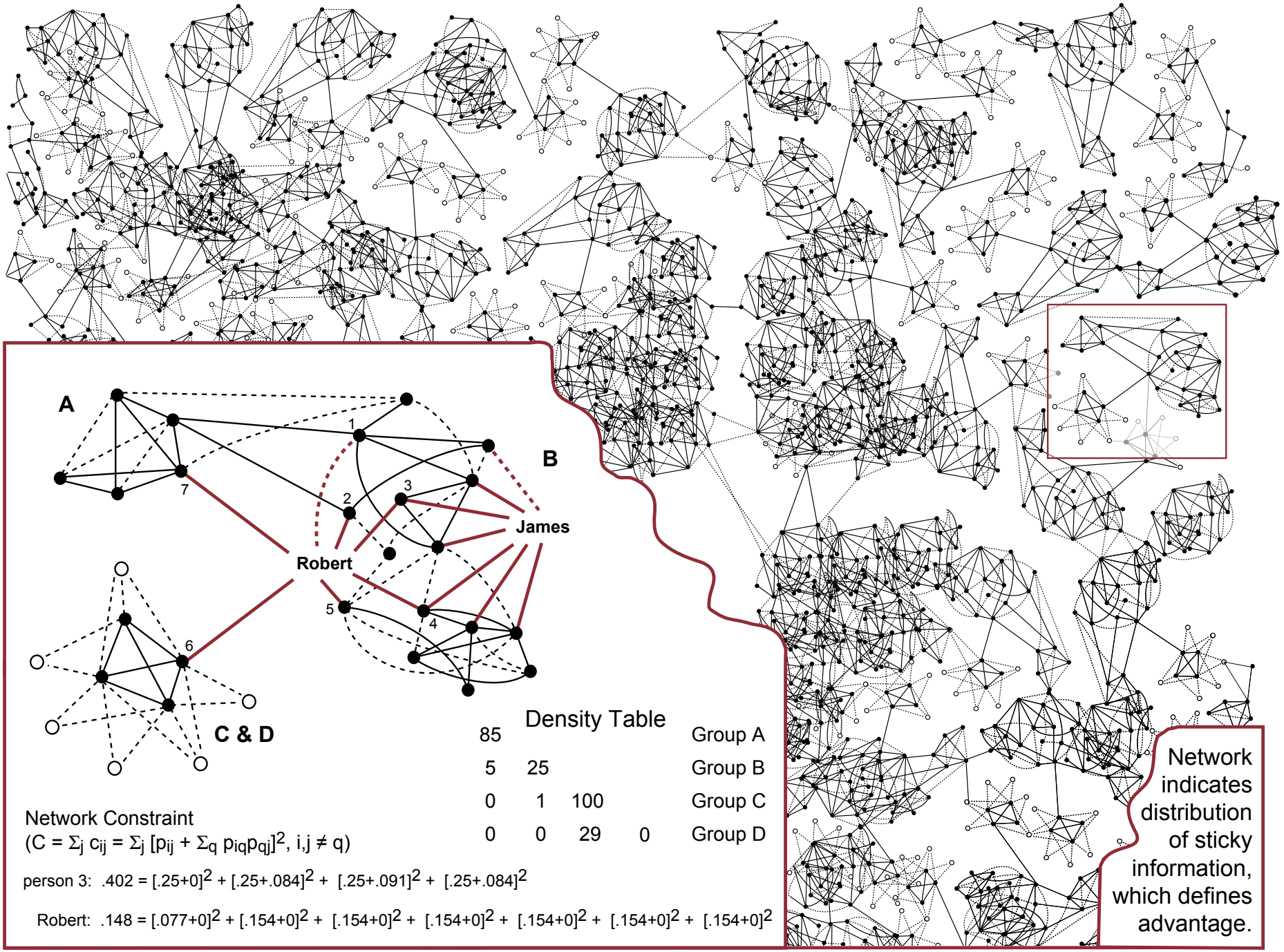
Elihu Katz 1926 - 2021

Network models of advantage are grounded in two facts about the social distribution of information from the 1950s "golden age" of social psychology (e.g., Festinger, Schachter & Back, 1950; Asch, 1951; Schachter, 1951; Katz & Lazarsfeld, 1955): (1) people cluster into groups as a result of contact opportunities defined by the places where people meet, and (2) communication is more frequent and influential within than between groups so that people in the same group develop similar views.

People tire of repeating arguments and stories explaining why they believe and behave the way they do. Within a group, people create systems of phrasing, opinions, symbols and behaviors defining what it means to be a member. Beneath the familiar arguments and experiences are new, emerging arguments and experiences awaiting a label, the emerging items more understood than said within the group. What was once explicit knowledge interpretable by anyone becomes tacit knowledge meaningful primarily to insiders. With continued time together, information in the group becomes "sticky" – nuanced, interconnected meanings difficult to understand in other groups (Von Hippel, 1994). Much of what we know is not easily understood beyond the colleagues around us. Holes tear open in the flow of information between groups. These holes in the social structure of communication, or more simply structural holes (Burt, 1992), are missing relations indicating where information is likely to differ on each side of the hole and not flow easily across the hole. In short, the bridge and cluster structure in social networks indicates where information is relatively homogeneous (within cluster) and where information is likely to be heterogeneous (between clusters).

From Burt, "Network disadvantaged entrepreneurs" (*Entrepreneurial Theory and Practice*, 2019, page 22)

Bridge & Cluster: Small World of Organizations & Markets



Density Table

85				Group A
5	25			Group B
0	1	100		Group C
0	0	29	0	Group D

Network Constraint
$(C = \Sigma_j c_{ij} = \Sigma_j [p_{ij} + \Sigma_q p_{iq}p_{qj}]^2, i,j \neq q)$

person 3: $.402 = [.25+0]^2 + [.25+.084]^2 + [.25+.091]^2 + [.25+.084]^2$

Robert: $.148 = [.077+0]^2 + [.154+0]^2 + [.154+0]^2 + [.154+0]^2 + [.154+0]^2 + [.154+0]^2 + [.154+0]^2$

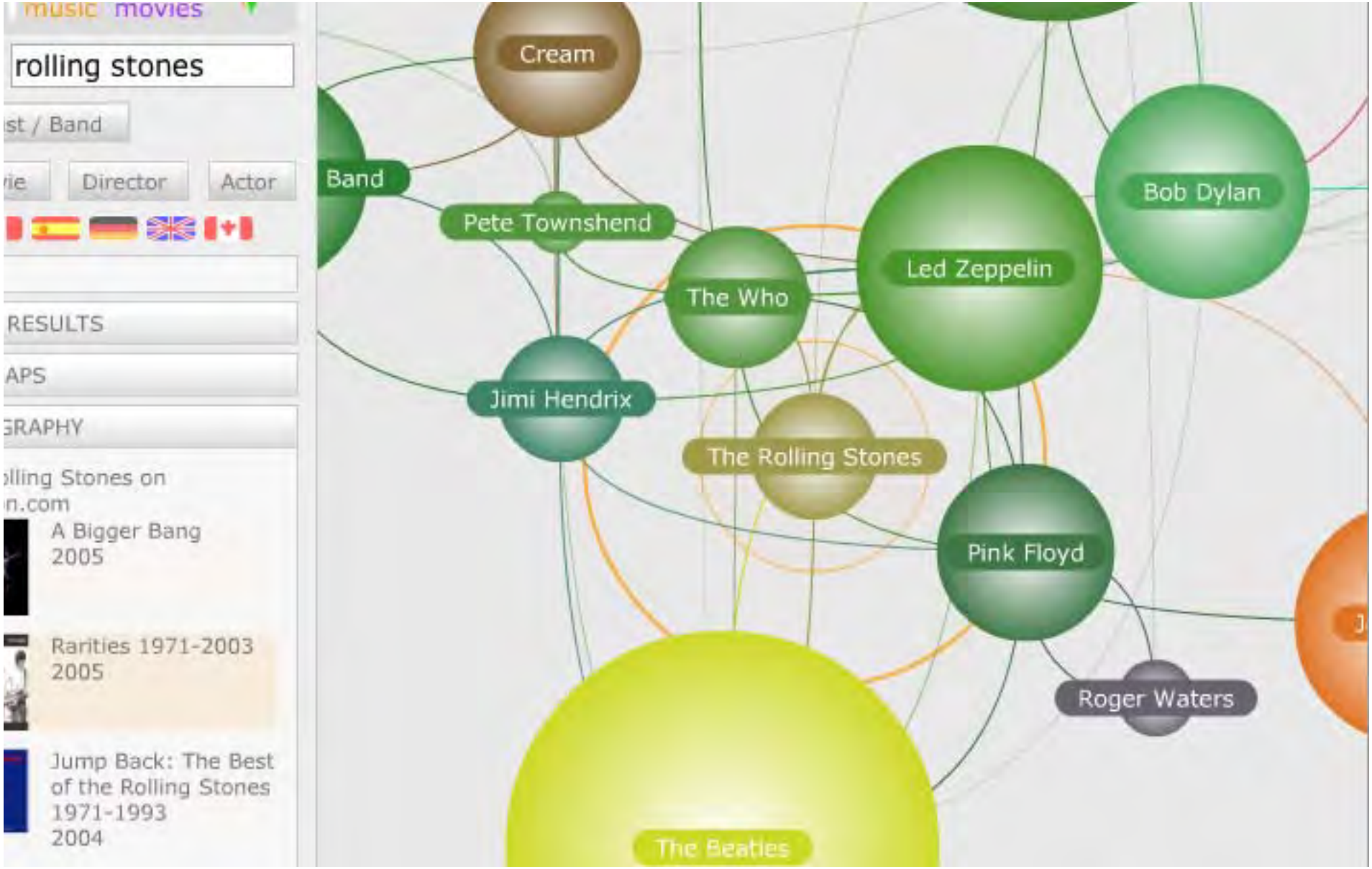
Network indicates distribution of sticky information, which defines advantage.

From Figure 1.1 in *Brokerage and Closure.*

amazon.com
list of related products (customers who bought this also bought . . .)

yasiv.com
bridge-and-cluster structure (until Amazon changed access)

musicplasma.com
11/2005 results for rolling stones



Network structures have inertia in that they tend to reproduce themselves, preserving the status quo. Here are three often-cited examples:

(1) **Preferential Attachment**: The probability of a new relationship forming with a person who has M contacts increases with M. In other words, new relationships accumulate around popular people. (Barabasi-Albert 2000 *Science*; Simon 1955 *Biometrika*; see Wikipedia entry; application: Feld 1991 *AJS* using Coleman 1961 data; Christakis 2023 talk)

(2) **Network Power Law**: Number of contacts decreases with number frequency; e.g., number of people with M contacts is predictable from $f(M) = aM^{-b}$ (cofficients a and b are to be estimated, b often between 2 and 3). In other words, many people have few contacts and a few people have many contacts (versus a bell curve in which most people have an average number of contacts). (Barabasi-Albert 2000 *Science*; Simon 1955 *Biometrika*; Zipf 1949 book; see Wikipedia "scale free"; Newman 2005 *Contemporary Physics*)

(3) **Bridge Decay**: Relations within groups decay more slowly than relations between groups. In other words, groups tend to reproduce themselves. This is a general implication of the many embedding theories in social science. (Burt 2002 *Social Nets*; Krackhardt 1998 Simmelian ties; Feld 1997 *Social Nets*; Newcomb 1961 book on balance)

Much of management research is about network inertia holding people back, but of special interest are the people who break free of inertia. That is our target, and it largely turns on access to diverse kinds of knowledge — or more generally, access to diverse kinds of information — associated with network clustering.

Create Value by Bridging Structural Holes

STICKY INFORMATION
Information expensive to move because: (a) tacit, (b) complex, (c) requires other knowledge to absorb, or (d) interaction with sender, recipient, or channel.

STRUCTURAL HOLE
disconnection between two groups or clusters of people

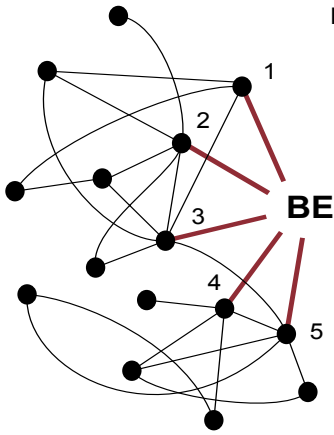
BRIDGE
relation across structural hole

NETWORK ENTREPRENEUR
or "broker," or "connector:"
a person who coordinates across a structural hole

BROKERAGE
act of coordinating across a structural hole

Here is the core network for a job BEFORE and AFTER the employee expanded the network advantage of the job by reallocating network time and energy to more diverse contacts.

It is the weak connections (structural holes) between contacts in the AFTER network that provides expanded network advantage.

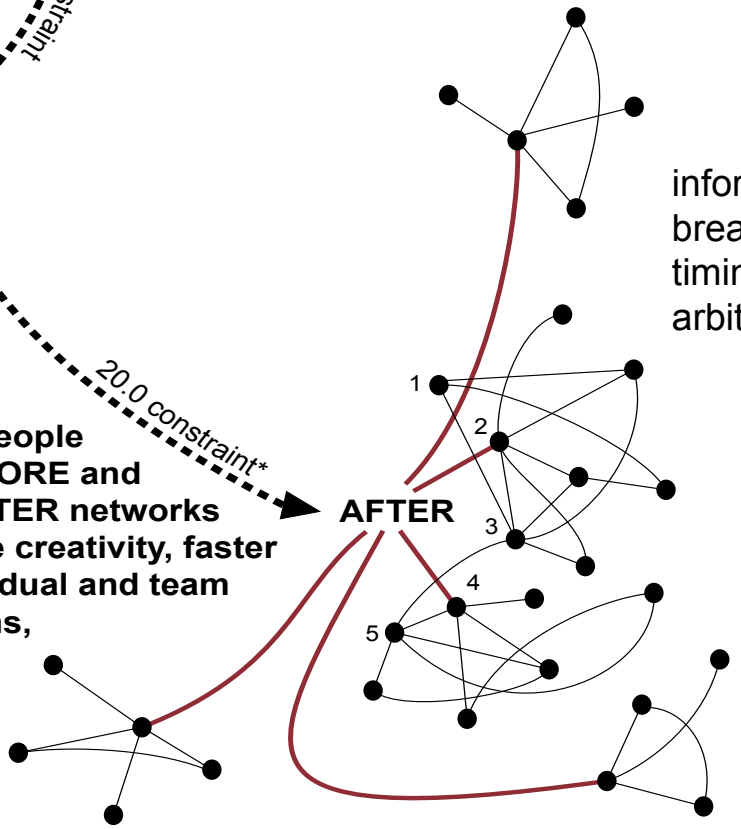


The employee AFTER is more positioned at the crossroads of communication between social clusters within the firm and its market, and so is better positioned to craft projects and policy that add value across clusters.

53.6 constraint

Research shows that employees in networks like the AFTER network, spanning structural holes, are the key to integrating operations across functional and business boundaries. In research comparing senior people with networks like these BEFORE and AFTER networks, it is the AFTER networks that are associated with more creativity, faster learning, more positive individual and team evaluations, faster promotions, and higher earnings.

20.0 constraint*

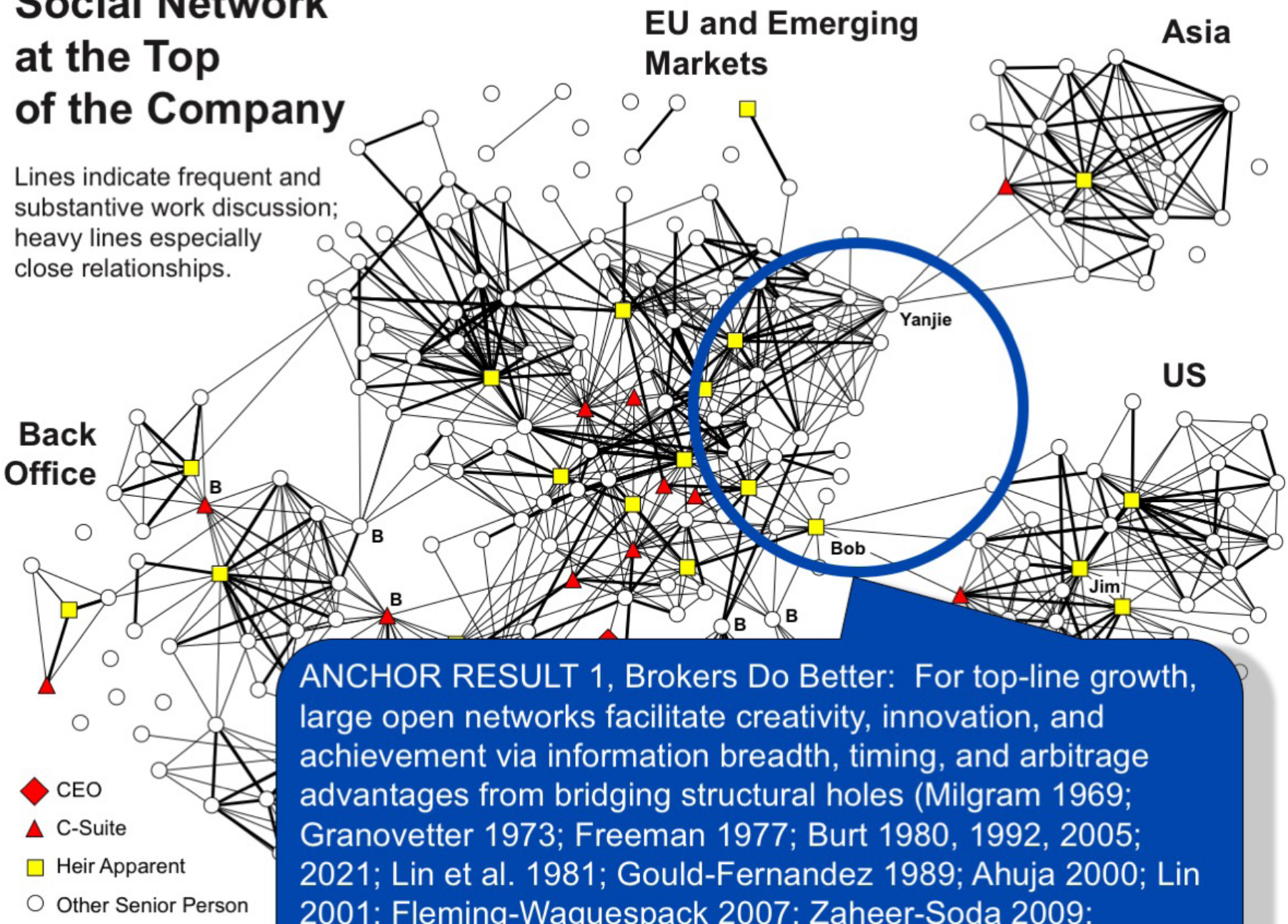


information breadth, timing, and arbitrage

*Network scores refer to direct contacts.

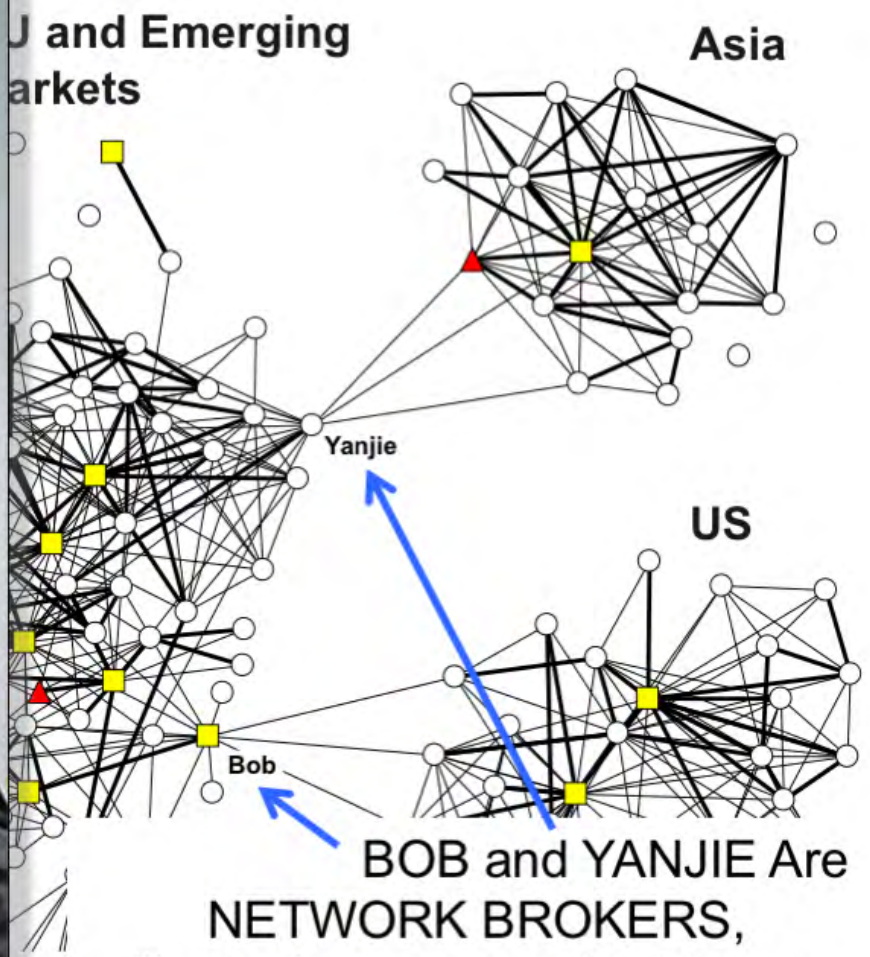
From Figure 1.4 in Burt (1992 *Structural Holes)*, and Figure 1.2 in *Brokerage and Closure*.
See Appendix I on survey network data, Appendix IV on measuring network constraint.

Social Network at the Top of the Company



ANCHOR RESULT 1, Brokers Do Better: For top-line growth, large open networks facilitate creativity, innovation, and achievement via information breadth, timing, and arbitrage advantages from bridging structural holes (Milgram 1969; Granovetter 1973; Freeman 1977; Burt 1980, 1992, 2005; 2021; Lin et al. 1981; Gould-Fernandez 1989; Ahuja 2000; Lin 2001; Fleming-Waguespack 2007; Zaheer-Soda 2009; Goldberg et al. 2016; Soda-Tortoriello-Iorio 2018; Brass 2022).

Alex Zaffaroni, serial entrepreneur in Silicon Valley biotech - e.g., Affymax



(Huateng "Pony" Ma, founder-CEO Tencent)

BOB and YANJIE Are NETWORK BROKERS, illustrating a general guidance: Broaden your network across structural holes between groups (creating information advantages of breadth, timing, and arbitrage across groups) to promote innovation and growth.

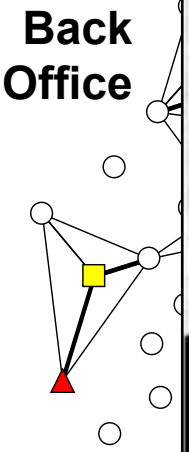
Social
at the
of the

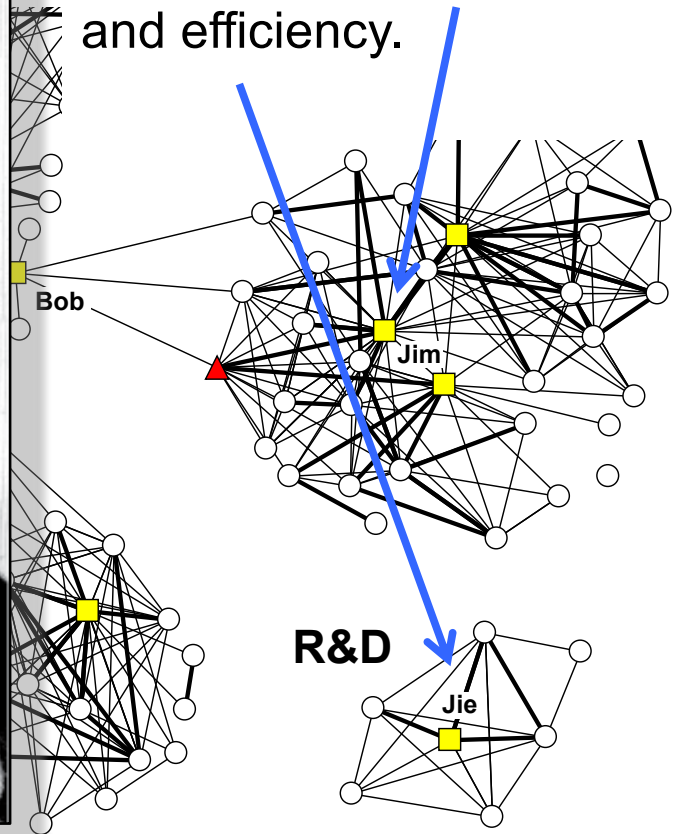
Lines indic
substantiv
heavy line
close relat

JIM and JIE are WARLORDs in their businesses, Illustrating the other rule of network advantage:

Close the network around your contacts to promote trust and efficiency.

Back Office





CEO
C-Suite
Heir App
Other S

(“The Bull,” 1917 Berlin political cartoon of Bavarian bourgeois)

Practice Can Be Limited by Tech. Price variation indicates sticky information. Graphs show variation in fish prices before and after cell phones are available to fishermen.

Weekly surveys were conducted with sample wholesalers in three regions for a common category of fish sold (sardines). Regions are administrative districts in the Indian state of Kerala.

Network brokers are a mechanism that clears sticky information in a market.

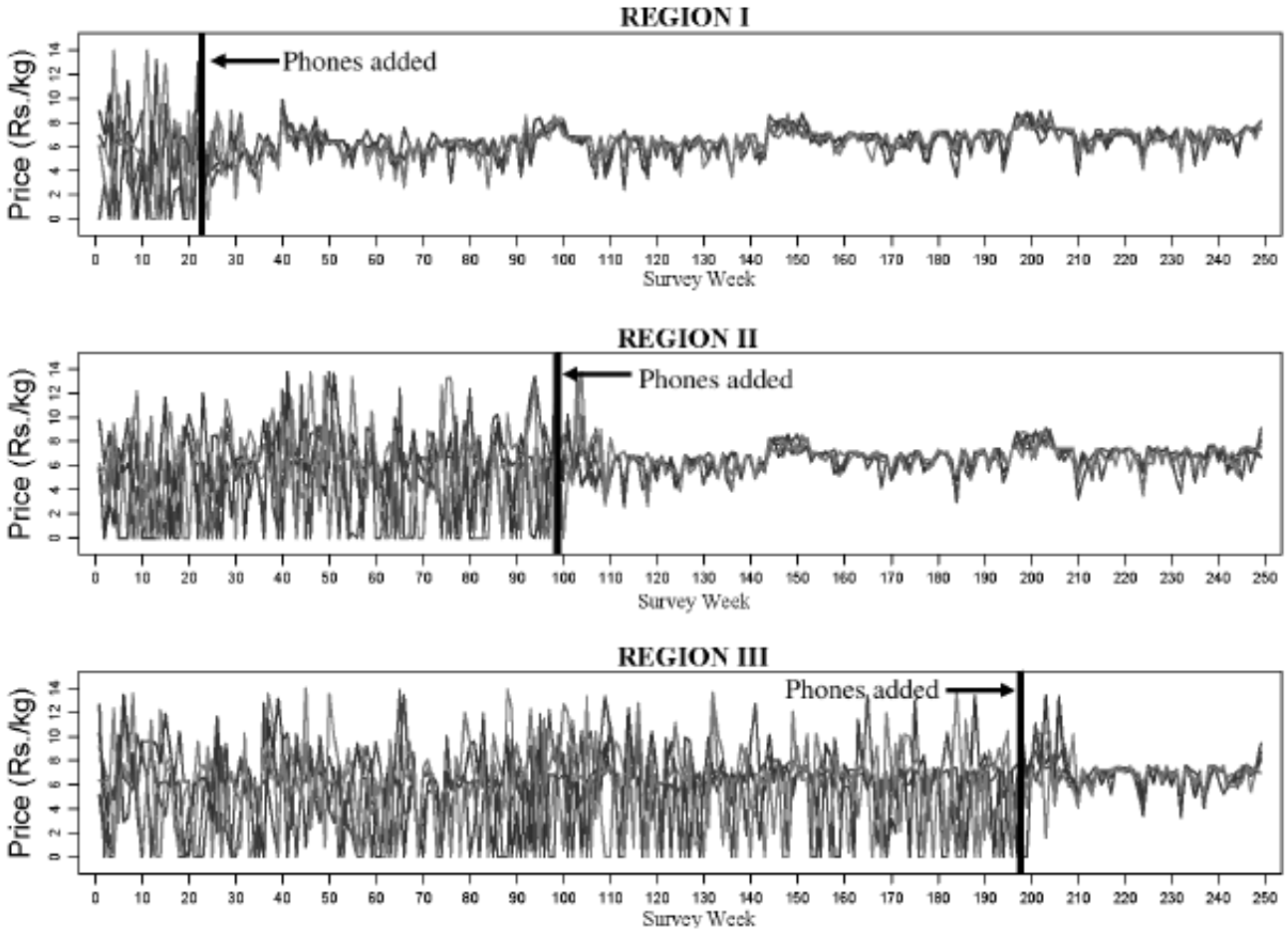


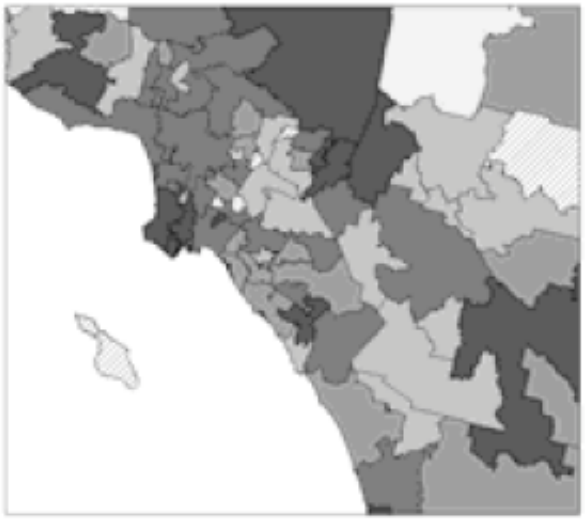
Figure 4 in Jensen, "The digital divide: information (technology), market performance, and welfare in the south Indian fisheries sector" (2007 *Quarterly Journal of Economics*).

And Sometimes Practice Is Limited by Convention.

dartmouthatlas.org: geographic bridge-and-cluster network of medical practice

In the Pacific States, hospital service areas that perform more diagnostic tests for coronary artery disease per thousand Medicare enrollees had higher rates of invasive treatment.

San Francisco



Los Angeles

BusinessWeek Investor HEALTH

To Cut —Or Not to Cut?

Deciding whether a surgical operation recommended by your doctor is right for you. BY KATE MURPHY

ARE SURGEONS too quick to put patients under the knife? That's an important question for anyone considering a coronary bypass, hysterectomy, prostate removal, or a long list of other common elective operations. Studies recently released by Dartmouth College researchers show tremendous "unwarranted variations" in the numbers of invasive procedures performed in the U.S. In other words, the likelihood of your having surgery depends more on the doctor you see than whether you really need an operation.

Avoiding unnecessary surgery requires a proactive patient willing to challenge opinions and research options. "One of the biggest problems with our health-care system is that patients are way too passive," says Dr. Robert Brook, director of health policy research at the RAND Corp.

Doctors have biases that may conflict with your best interest. A urologist is more inclined to recommend surgery for prostate cancer, while a radiotherapist is likely to tell you to have radiation. An orthopedic surgeon will lean toward back surgery for disk compression, while a sports medicine doctor will more often advise physical therapy.

Not surprisingly, money often comes into the equation. "The system does not reward doctors for talking. It rewards them for doing," says Megan Cooper, editor of the Dartmouth Atlas project, which tracks health-care expenditures across the nation. Patient advocates say it's no coincidence that the most commonly performed procedures are also the most expensive. "If coronary bypass surgery cost $500, you can bet doctors wouldn't be doing so many of them," says Charles Inlander, president of the People's Medical Society, a consumer group in Allentown, Pa. A typical bypass operation runs $39,000 to $123,000, with the surgeon's fee ranging from $5,000 to $20,000.

Indeed, Gerald Hines, chairman of Hines Interests, a real estate development firm in Houston, weighed the monetary motive when he decided years ago against two cardiac surgeons' recommendations that he get a triple bypass. "You have to be reflective when the cost is such a large amount," he says. Besides, "I didn't want someone opening up my chest." Instead, under the supervision of his internist, he followed a strict low-fat diet, started an exercise regime, and practiced yoga and meditation. He also took a beta-blocker drug, which reduces the rate and force of heart contractions. That was more than 20 years ago. Now 78, Hines is orchestrating his company's overseas expansion. "I feel great," he says.

GET MULTIPLE OPINIONS

With this in mind, never accept one doctor's word that you need an invasive procedure. Be especially wary if it's one of the "big-ticket" operations that insurance investigators and patient advocates say are overdone (table, right). You should also check the Dartmouth Atlas project's Web site (www.dartmouthatlas.org) to see if it is a procedure that is performed in your area at a rate far higher than the national average. By clicking on "Custom Reports" and entering your state under "Community Profile Reports," you can find, for example, that there are suspiciously high numbers of back sur-

PHOTOGRAPH BY ROBERT LLEWELLYN/IMAGESTATE-PICTOR/PICTUREQUEST; ILLUSTRATION BY ALBERTO MENA/BW

Now for the Social Network
Here Is an Example "Name Generator" Question

(This is a variation on the "name generator" used in the General Social Survey, GSS, upon which many other surveys are based.)

We begin with a sketch of your core discussion network at the current time. From time to time, most people discuss important matters with other people. What constitutes an "important matter" can be different for different people, but important matters usually involve your family, work, hopes, frustrations, current events, hobbies, and so on. The people with whom we discuss important matters are equally diverse: relatives, friends, neighbors, colleagues at work, and so on.

In order to answer the questions on the next few screens, you'll need to enter the names of people, but we have no interest in the names and we want to preserve your and their confidentiality. So please just list people by their nickname. If you list two people with the same nickname, please list the repeats by nickname and last initial. For example, Ronald Burt would be listed as Ron B.

With the above in mind, think about the last six months. Please enter to the right the nicknames and last initials of the 6 or 7 people with whom you recall discussing matters important to you. Please just enter nicknames and initials. Where relevant, make an effort to include recent discussion partners at Bocconi.

Sonja O
Don R
Beppe S
Nicolo C
Dan B
Anna G
Stefano P
Doug S

Argument for the "discussing important matters" name generator is in the proposal to introduce network data in the GSS (Burt, 1984:315-320, *Social Networks*). Particularly important was the fact that the GSS generator should elicit names elicited by a variety of alternative name generators. Earlier work shows that the proposed GSS generator likely lies in the middle of the content space of alternatives (as illustrated by the multidimention scaling to the right from Burt and Minor, 1983:47, *Applied Network Analysis*).

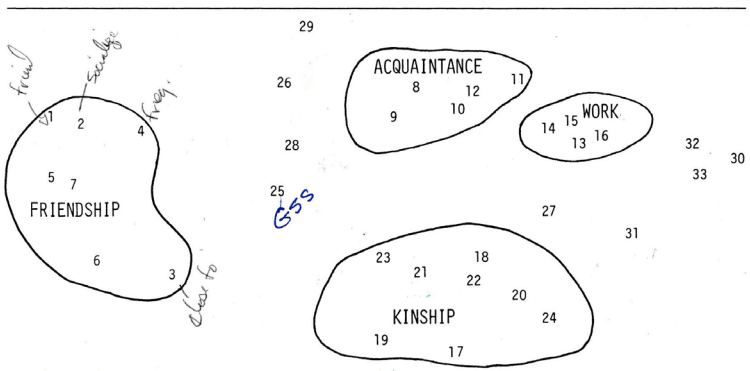
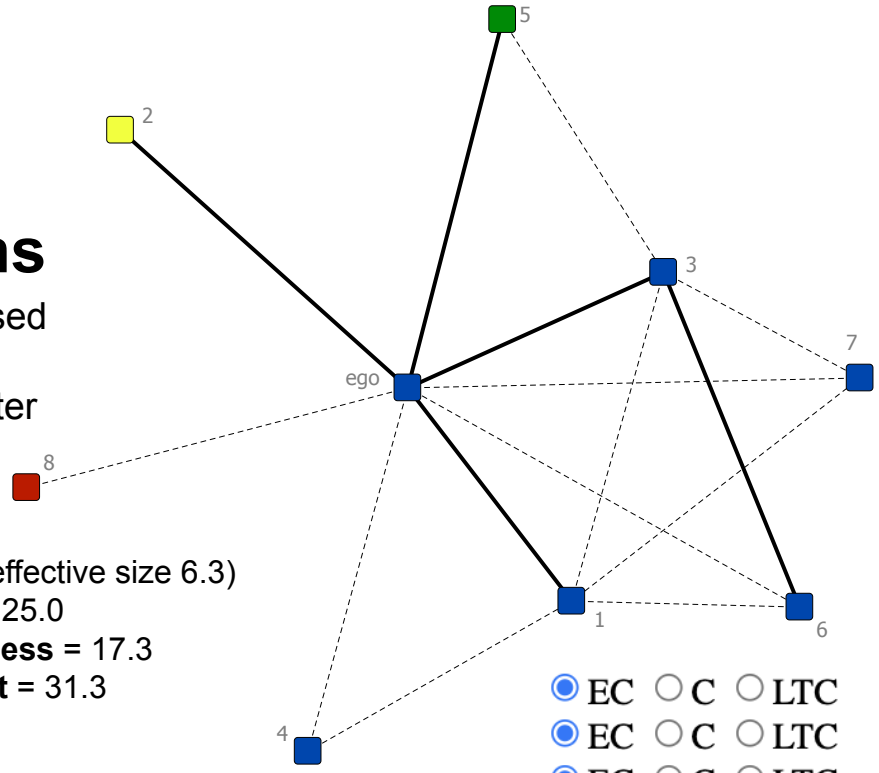


Figure 2.1: Spatial Representation of Substitutability Among the Relational Contents Listed in Table 2.2 (contents are proximate in the space to the extent that they were used substitutably by survey respondents; content domains are circled)

And Example
"Name Interpreter" Questions

(The below are a variation on "name interpreters" used in the General Social Survey, GSS, upon which many other surveys are based. Interpreter questions typically include phenomenon-relevant attributes of contacts, e.g., kind of relation, function, rank, geography, etc.)



size = 8 (effective size 6.3)
density = 25.0
betweenness = 17.3
constraint = 31.3

Please click the box next to each name that best describes how close you feel with each listed person. For each person, are you ”especially close” (EC), “close” (C), or“less than close” (LTC)?

◉ EC	○ C	○ LTC	Sonja O
◉ EC	○ C	○ LTC	Don R
◉ EC	○ C	○ LTC	Beppe S
○ EC	◉ C	○ LTC	Nicolo C
◉ EC	○ C	○ LTC	Dan B
○ EC	◉ C	○ LTC	Anna G
○ EC	◉ C	○ LTC	Stefano P
○ EC	○ C	◉ LTC	Doug S

Next, please think about connections between the people you mentioned. Some of them can be total strangers in the sense that they wouldn't recognize the other person if they bumped into one other on the street. Some of them can be especially close, as close or closer to each other as they are to you.

On this screen, please click the appropriate box to describe connections between **SONJA O** and each other person: "S" for total strangers. "EC" for especially close. Click the middle button, "M" if they are neither strangers nor especially close.

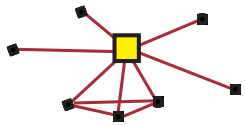
○ EC	○ M	◉ S	Don R
○ EC	◉ M	○ S	Beppe S
○ EC	◉ M	○ S	Nicolo C
○ EC	○ M	◉ S	Dan B
○ EC	◉ M	○ S	Anna G
○ EC	◉ M	○ S	Stefano P
○ EC	○ M	◉ S	Doug S

MEASUREMENT: contrast is between people rich in access to structural holes versus people without

(cosmopolitans vs locals in Merton 1949; opinion leaders vs followers in Katz & Lazarsfeld 1955; extensive vs intensive search in Rees 1966; leaders vs managers in Kotter 1990; exploration vs exploitation in March 1991; cultural omnivores vs univores in Peterson 1992; open vs closed networks, on the edge of worlds vs at the center; and of course, Schumpeter's 1911 touchstone image of entrepreneurial "leaders" bringing together elements from separate production spheres within which people live by routines)

Disconnected contacts provide rich access to structural holes

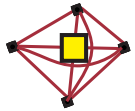
100% in one group provides no access to structural holes



0 10 20 30 40 50 60 70 80 90 100

Network Constraint

many ——— Structural Holes ——— few



Here network constraint – the extent to which a person's network is limited to a single group, which means they have no access to structural holes (other popular measures are size, density, and ego-network betweenness). Constraint increases as a network becomes **SMALL** (few alternative contacts), **DENSE** (strong relations between contacts), or **HIERARCHICAL** (central contact holds others together)

Data are easily available from surveys, 360˚, email, and other electronic trace (badges, chat rooms, social media, virtual worlds, etc.).

See Appendix I on network survey data, and Appendix II on measuring access to structural holes.

(Q149) **Compute network density for John's network** (to simplify the sociogram, John's connections are not shown).

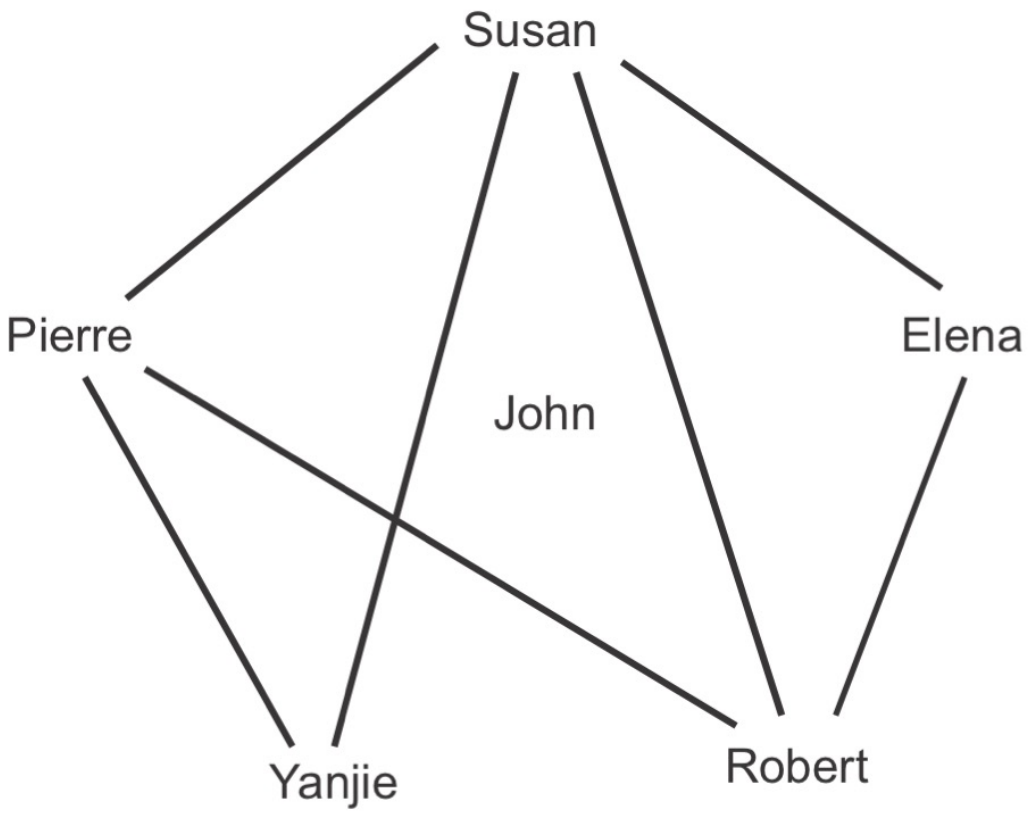
A. 30%

B. 47%

C. 60%

D. 70%

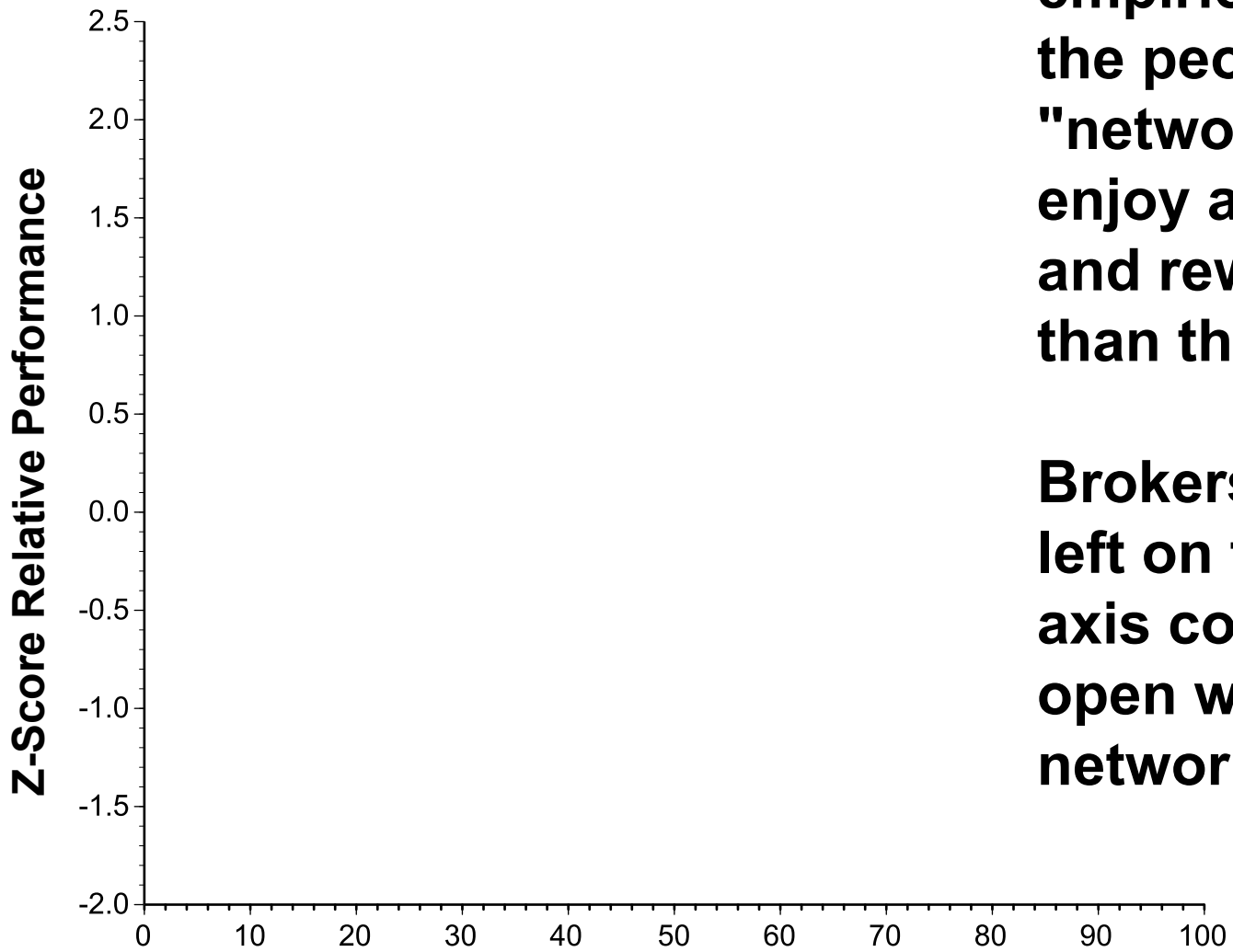
E. 90%

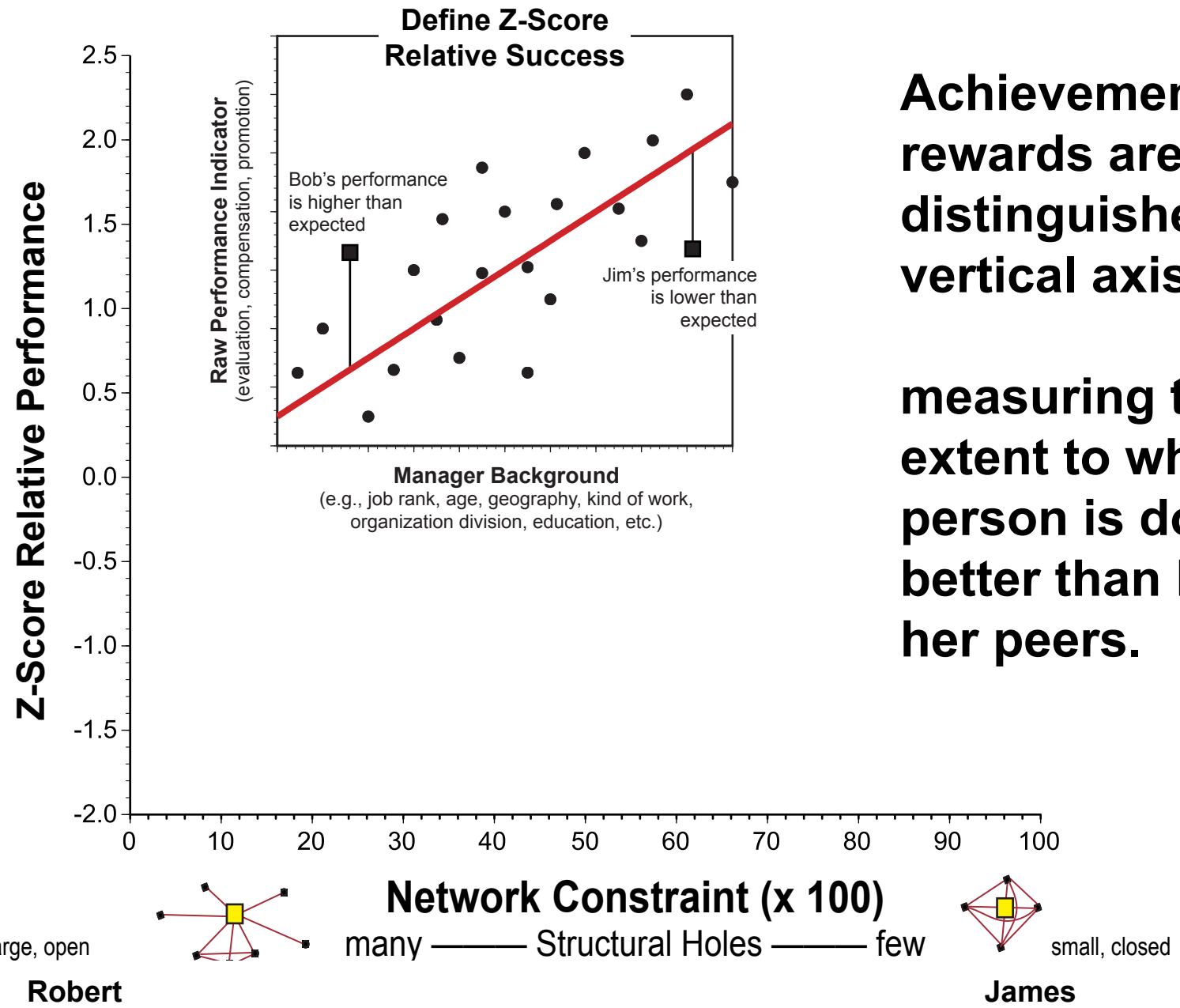


Density = average tie strength among contacts = sum of ties / number of ties

Now to establish the empirical fact that the people known as "network brokers" enjoy achievement and rewards higher than their peers.

Brokers are to the left on the horizontal axis contrasting open with closed networks.



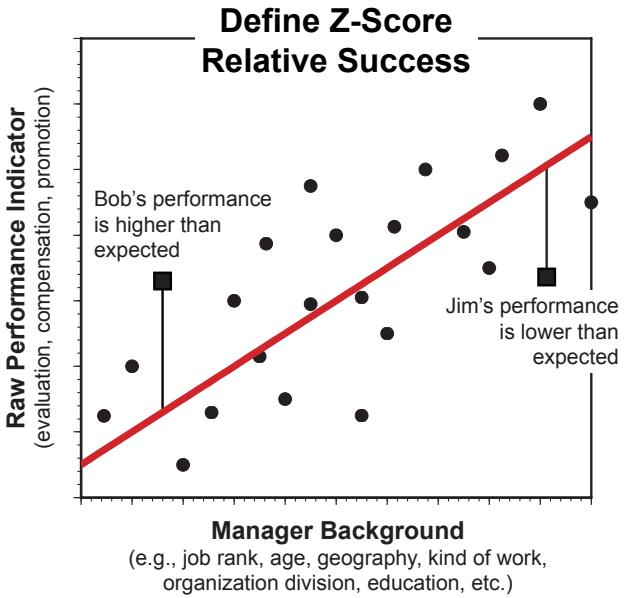


Achievement and rewards are distinguished on the vertical axis,

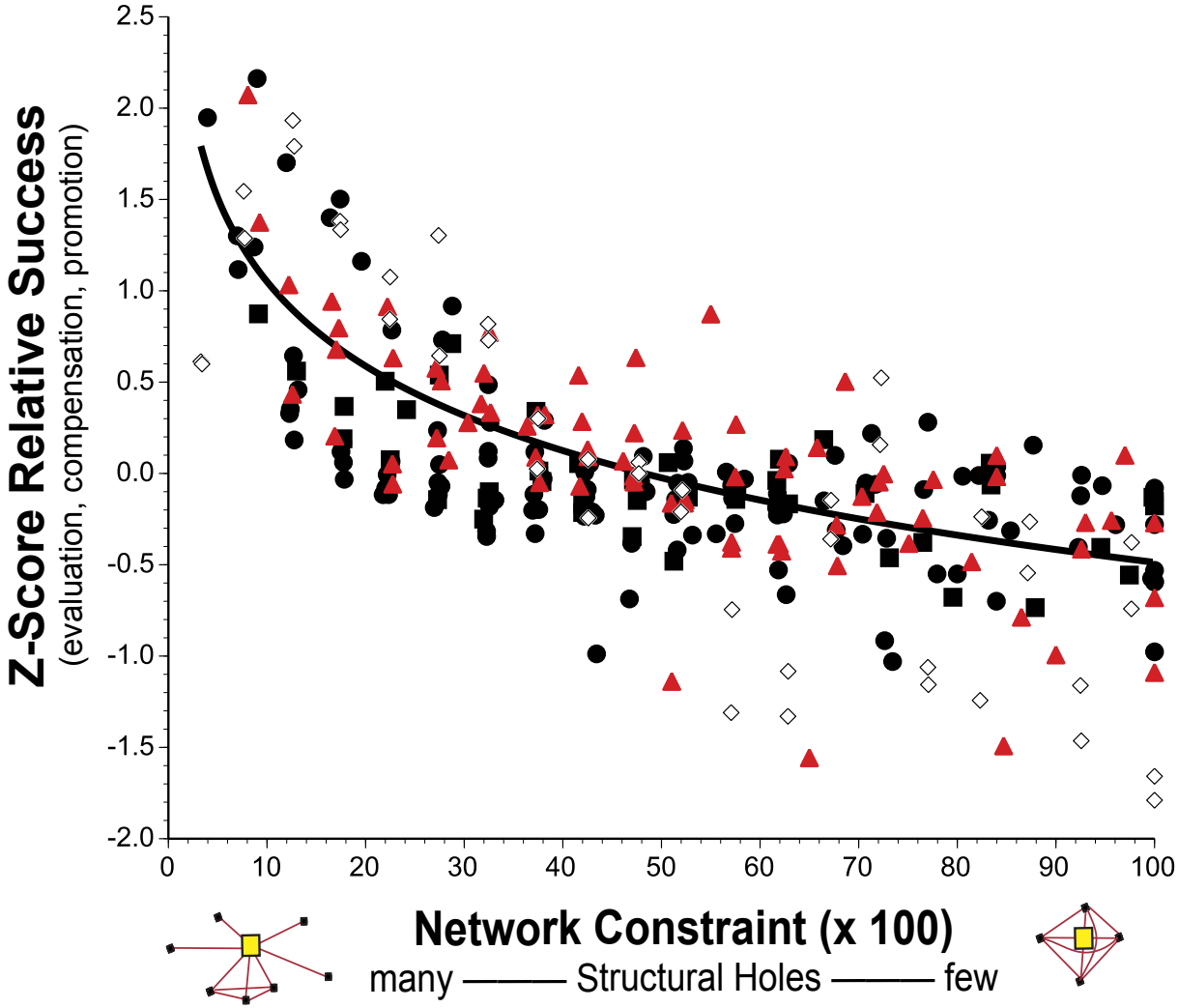
measuring the extent to which a person is doing better than his or her peers.

Brokers Do Better

(Success is less likely as the network around a person closes.)

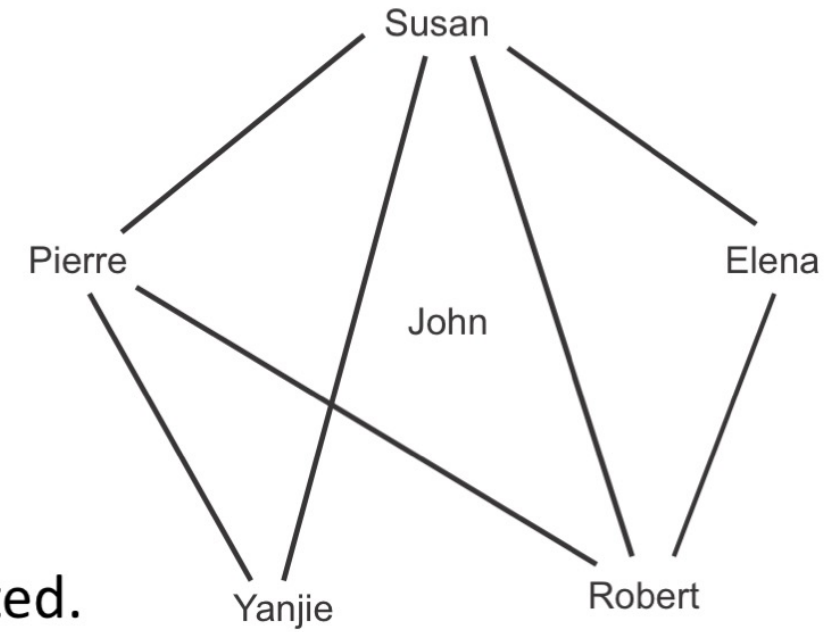


- Managers in the U.S. (n = 3093, 8 study pops, r = -.72)
- Managers in Europe (n = 1270, 4 study pops, r = -.70)
- Managers in Asia, Primarily China (n = 1591, 4 study pops, r = -.75)
- Virtual World (21536 avatars in EverQuest II, played by 13968 people, 2 samples, r = -.76)



NOTE — Plotted data are average scores within five-point intervals of network constraint within each study population. Correlations are computed from the plotted data using log network constraint. Inset graph to the upper left contains hypothetical data illustrating computation of z-score relative performance.

(Q150) **Using network density as a rough indicator of network constraint on John, do you expect him to be doing well or not so well in his career?**



A. Well, John's contacts are well connected.

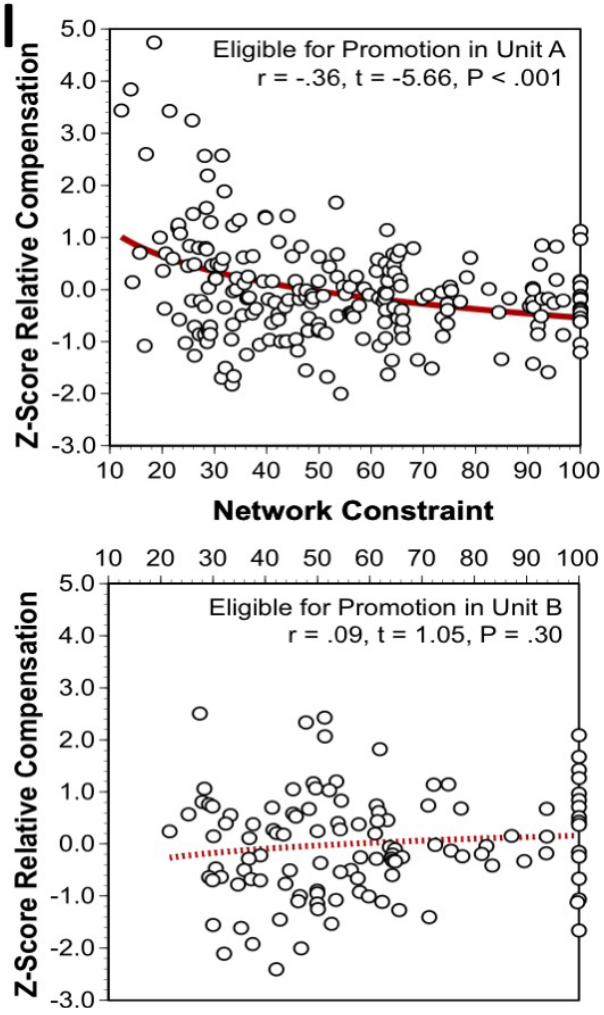
B. Well, Susan serves as a partner to John.

C. Not so well, John is disconnected.

D. Not so well, too many connections missing between contacts

E. Not so well, too many connections between contacts.

(Q151) For the last few years, the people promoted to senior positions in a company have come from one of two broad business units. The graphs to the right show compensation returns to manager networks within the two business units. **Which of the two units would you say is providing the successful promotions to senior positions, A or B?**



A. Business unit B, because there are more eligible people there.

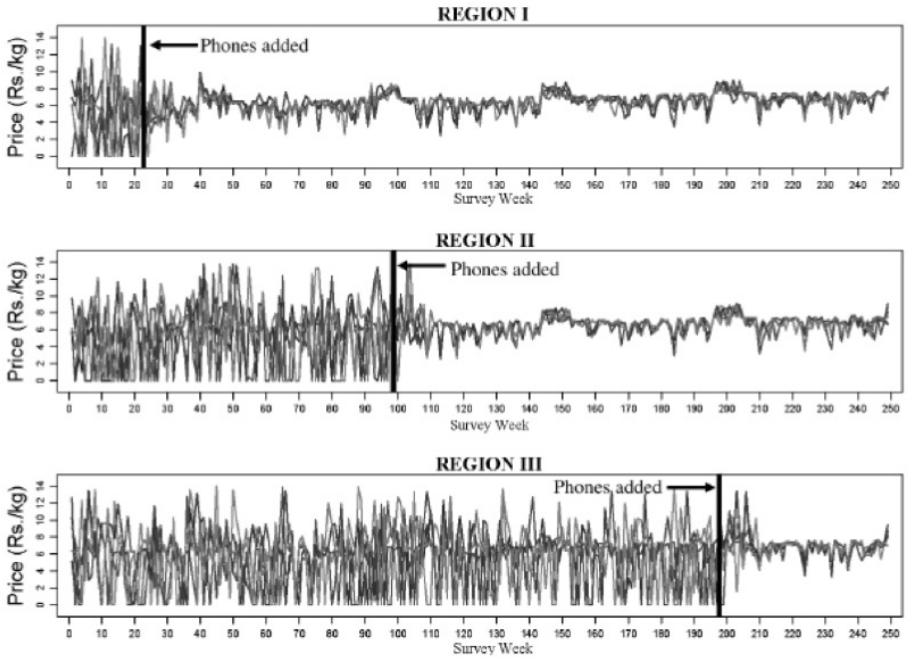
B. Business unit B, because interpersonal politics matter less there.

C. Business unit A, because manager networks vary more widely there.

D. Business unit B, because the fewer eligibles indicate rigorous pre-selection.

E. Business unit A, because there are more people rewarded for network brokerage.

(Q259) We discussed the below graph of prices before and after a technology change. **The transition from wide variation to narrow variation shows the effect of:**



A. Broader access to market information

B. Less noise in previously available information

C. More competitors in the market

D. Fewer competitors in the market

E. More sticky information in the market

(Q173) **For network brokerage to provide advantage, what is the most essential quality required in the surrounding organization or market?**

A. Exclusive access to people

B. Multiple social clusters

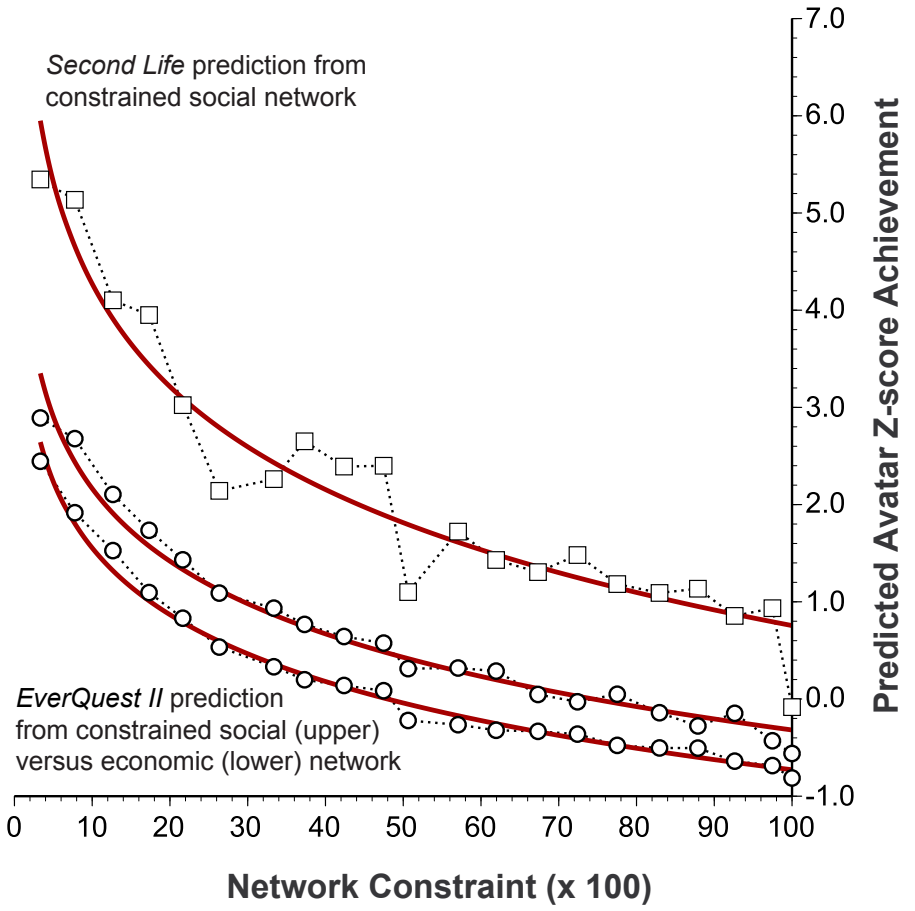
C. Information accuracy

D. Information variation

E. Large numbers of people

Returns to Brokerage Are Also Evident in Online Networks.

These are the returns to brokerage in two virtual worlds.



Dots are average Y scores within integer (left) or five-point (right) intervals on horizontal axis. *EverQuest II* achievement variable is the predicted character level in Model 8, Tables 3.4 and 3.5. *Second Life* achievement is the canonical correlation dependent variable in Model 15, Tables 3.5 and 3.6.

from Burt (*Structural Holes in Virtual Worlds*).

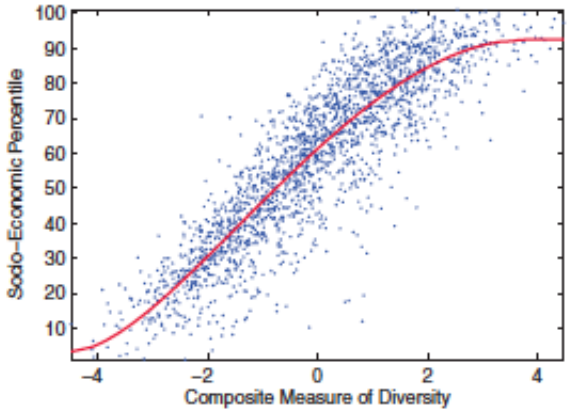
Returns to Brokerage Aggregate to Companies, Industries, and Communities

Fig. 1. An image of regional communication diversity and socioeconomic ranking for the UK. We find that communities with diverse communication patterns tend to rank higher (represented from light blue to dark blue) than the regions with more insular communication. This result implies that communication diversity is a key indicator of an economically healthy community. [(29) Crown copyright material is reproduced with the permission of the Controller of Her Majesty's Stationery Office]

People with phone networks that span structural holes live in communities higher in socio-economic rank

Networks are defined by land-line & mobile phone calls (map to left). Socio-economic rank is UK government index of multiple deprivation (IMD) based on local income, employment, education, health, crime, housing, and environmental quality (graph below). Units are phone area codes.

Fig. 2. The relation between social network diversity and socioeconomic rank. Diversity was constructed as a composite of Shannon entropy and Burt's measure of structural holes, by using principal component analysis. A fractional polynomial was fit to the data.



figures from Eagle, Macy, and Claxton (2010 *Science*), "Network diversity and economic development"

Returns to Brokerage Are Evident in Low Returns to Over-Specialized Students

Recent scholarship on the returns to labor market specialization often claims that being specialized is advantageous for job candidates. We argue, in contrast, that a specialist discount may occur in contexts that share three features: strong institutionalized mechanisms, candidate profiles with direct investments that signal their value, and a high supply of focused candidates relative to demand. We then test whether there is a specialist discount for graduating elite MBAs, as it is a labor market that exemplifies these conditions under which we expect specialists to be penalized. Using rich data on two graduating cohorts from a top-tier U.S. business school (full-time students, 2008-2009), we show that elite MBA graduates who established a focused (specialized) market profile of experiences relating to investment banking before and during the program were less likely to receive multiple job offers and were offered less in starting-bonus compensation than similar MBA candidates with no exposure or less-focused exposure to investment banking. Our theory and findings suggest that the oft-documented specialist advantage may be overstated.

Figure 1 displays predicted (marginal) probabilities of receiving multiple offers for candidates who have mean values for each of the control variables but different profiles.

Figure 2 compares the starting bonuses of hypothetical job candidates with different profiles. Each hypothetical candidate is a single white male who graduated from a top-20 undergraduate institution, has above a 3.8 GPA, received more than one job offer, has the mean age and work experience characteristics (months, number of firms), accepts a job in I-banking, and earns the mean base salary for I-banking jobs in his 2008 cohort year. The only difference is the candidate's profile in terms of exposure to I-banking.

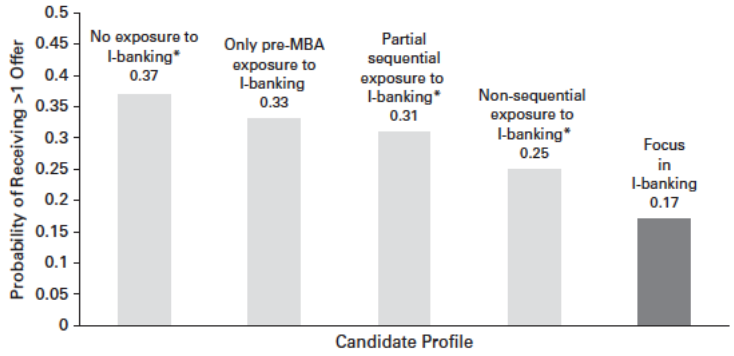
FOCUSED (career history in finance before mba, concentration in finance, joined an i-banking club during mba, and i-banking internship; 61% of students who graduate to a job in i-banking were focused on i-banking)

NON-SEQUENTIAL exposure (neither of the above categories, but some mba program contact with i-banking)

PARTIAL sequential exposure (prior experience in finance + concentration in finance or participation in i-banking club)

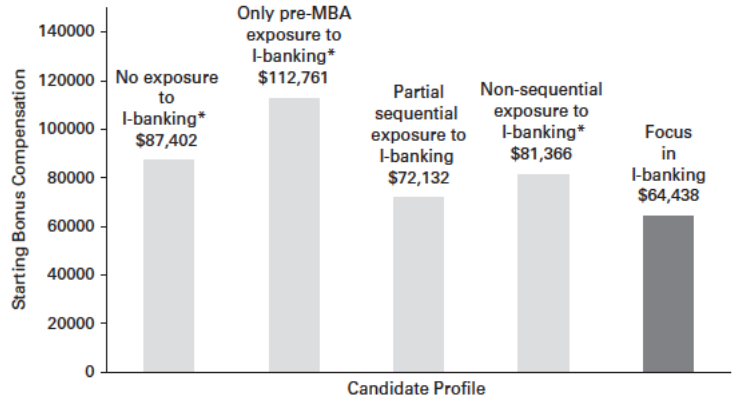
PRE-MBA exposure (only exposure before mba program)

Figure 1. Predicted probabilities of receiving more than one job offer for different candidate profiles using model 2 of table 2.



* Indicates that the profile is statistically different from a focus in I-banking.

Figure 2. Comparison of starting bonus amounts for a typical candidate with different profiles using model 2 of table 3.



* Indicates that the profile is statistically different from a focus in I-banking.

Figures and text are from Merluzzi and Phillips (2016 *Administrative Science Quarterly*), "The Specialist Discount." For more applied discussion, see Merluzzi, (June 2016 *HBR*), "Generalists get better job offers than specialists." Looking later in the career, Kleinbaum (2012 *ASQ*) "Organizational misfits," shows with email data that managers with unusual patterns of communication are most likely to emerge the valued network brokers.

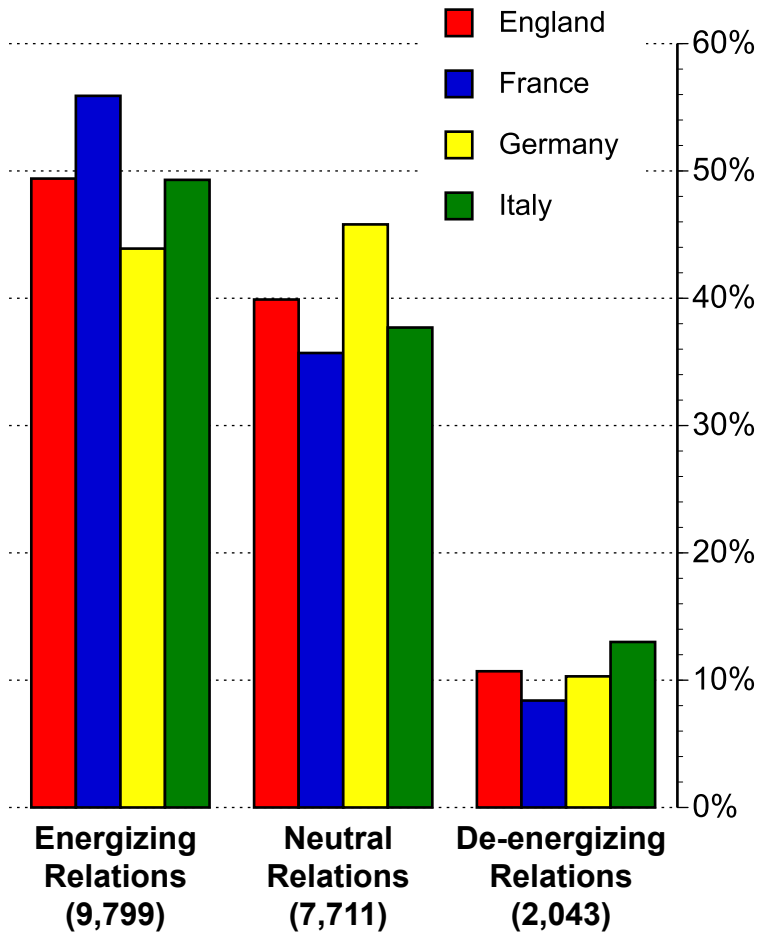
In addition to success — a long-run incentive to bridging structural holes — an immediate incentive is emotional energy. People feel more energized from social relations with their bridge contacts (relative to interaction with embedded contacts).

Name interpreter asked of 3,433 respondents in four 2023 national surveys about 19,553 cited discussion partners (GSS name generator):

"This network question distinguishes people by the energy you experience from talking with them.

People can affect the energy and enthusiasm we have in various ways. Interactions with some people can leave you feeling drained while others can leave you feeling enthused about possibilities. When you interact with each listed person, how does it typically affect your energy level?"

Please click the box next to each name that best describes whether talking with the person leaves you feeling energized (E), Neutral (N, no effect on your energy), or de-energized (DE).

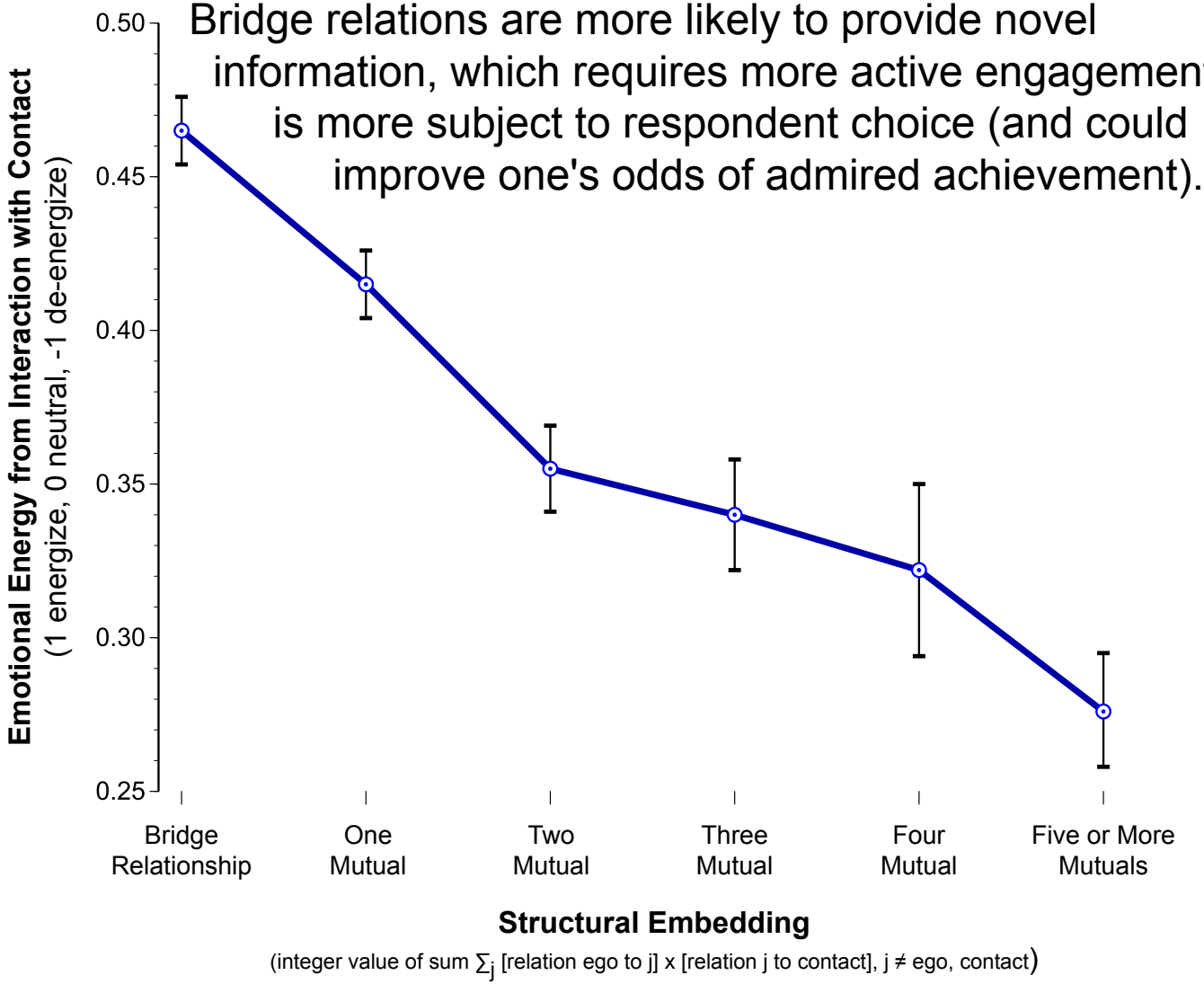


The more structurally embedded a relationship, the less likely it is described as a source of emotional energy.

These are levels of energy (and 95% confidence intervals) expected with structural embedding. Controls are imposed for respondent affection toward the other person (interaction with people we like is energizing), respondent differences in feeling energized by other people (some people enjoy socializing more than others), and differences between the three countries.

Energy level is associated with all the controls, but the hypothesized energy associated with bridge relationships remains strong, also with controls for relationshp content (kinds of family, work colleagues, and friends beyond work; see Burt, Opper, and Soda, 2023, "Emotional energy and structural holes").

Bridge relations are more likely to provide novel information, which requires more active engagement, is more subject to respondent choice (and could improve one's odds of admired achievement).



There is obviously a strong correlation between achievement and access to structural holes,

but does change in the network change the odds of achievement?

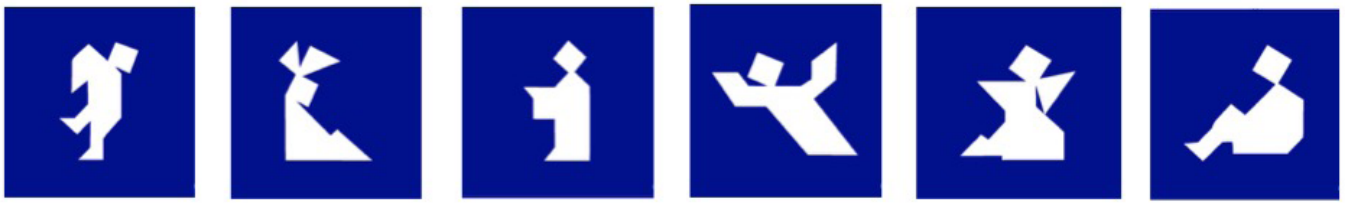
In other words,

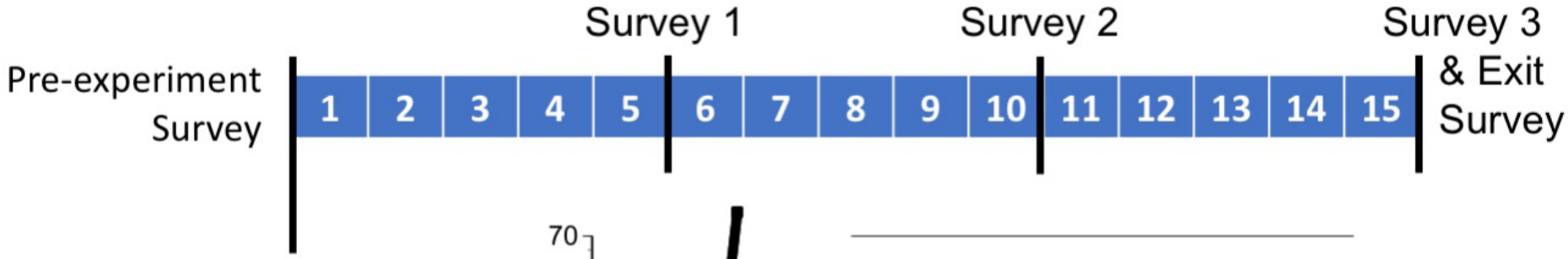
does the network have a causal effect on achievement?

Figure 1. Experiment Overview

People who bridge more team structural holes are more likely to be perceived as team leader.

Tangrams in 15 Tasks





GSS name generator: "From time to time, most people discuss important matters with other people, people they trust. The range of important matters varies from person to person across work, leisure, family, politics, whatever. The range of relations varies across work, family, friends, and advisors. *If you look back over the last six months, who are the five people with whom you most discussed matters important to you?*

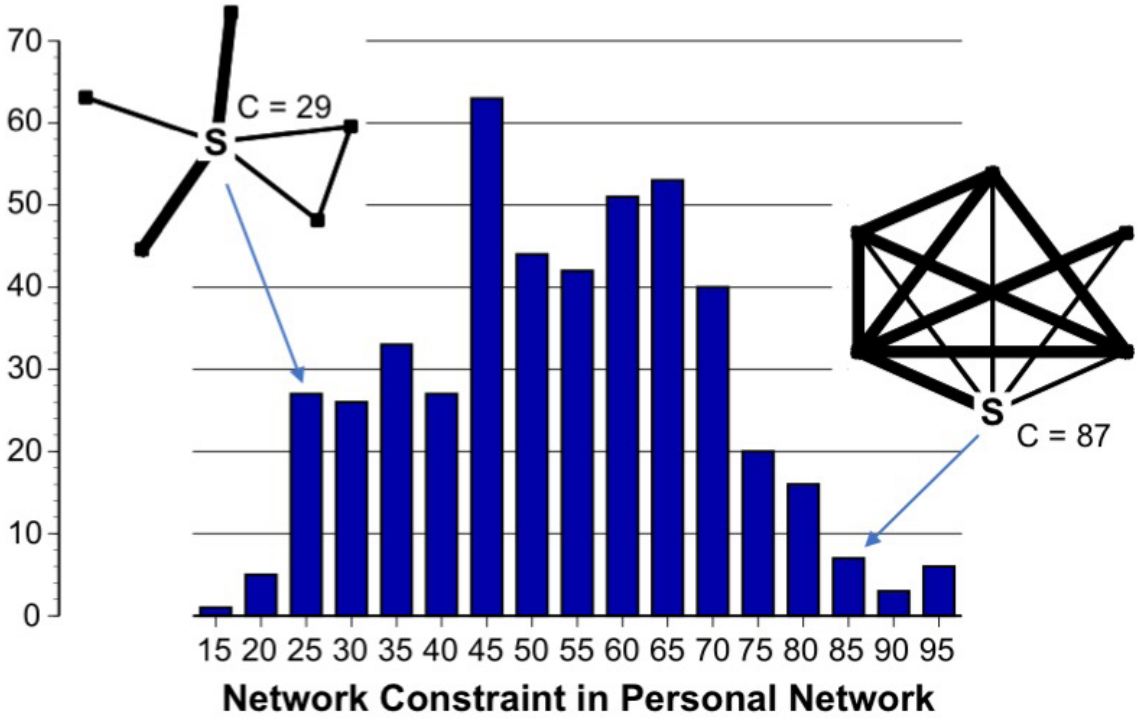
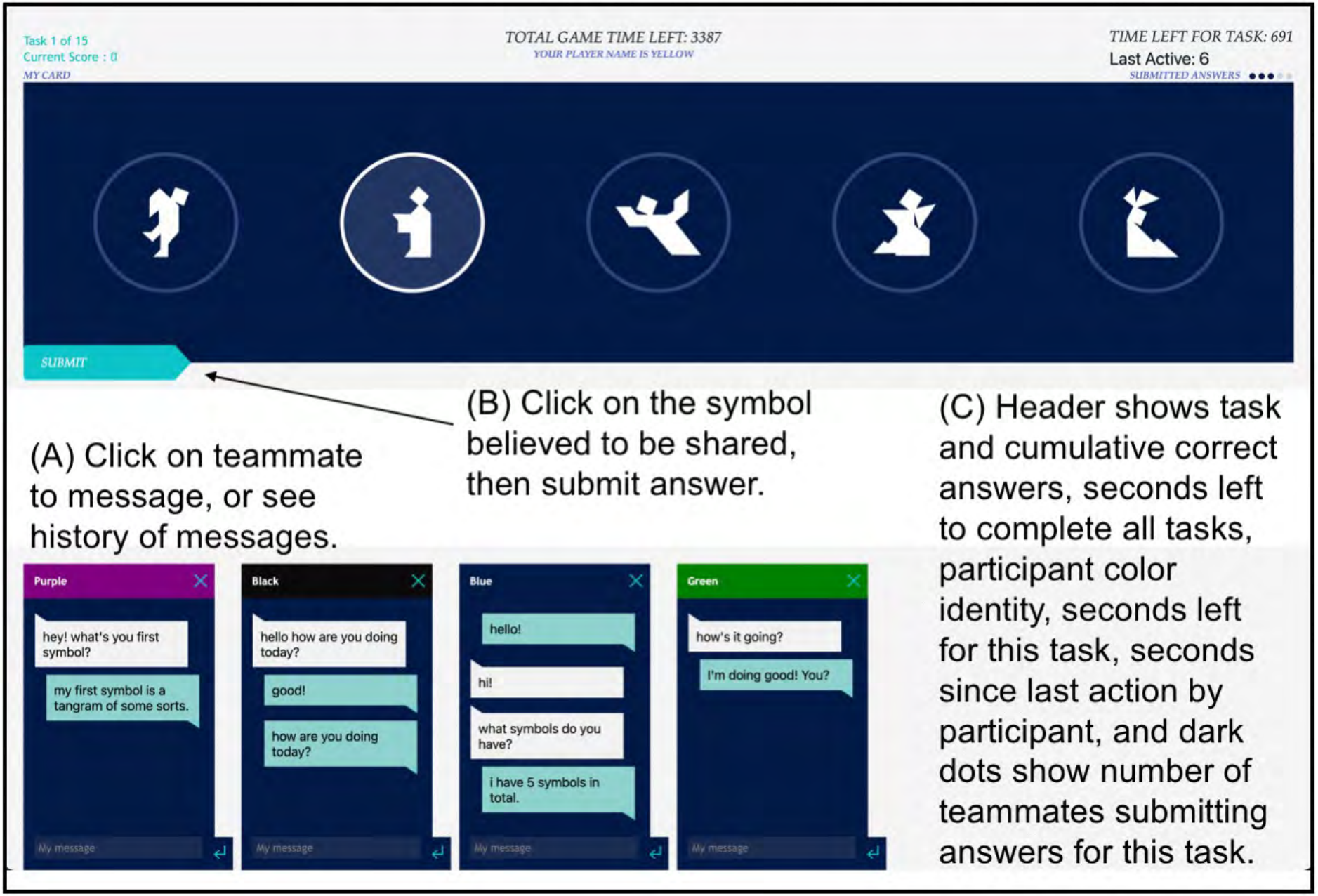
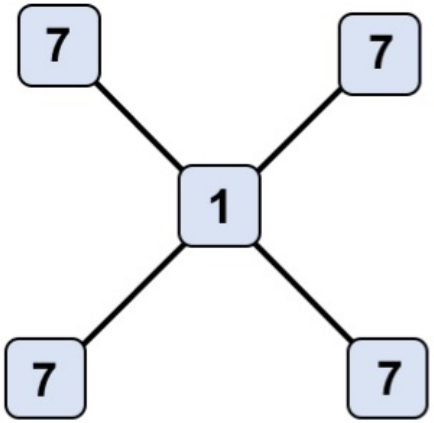
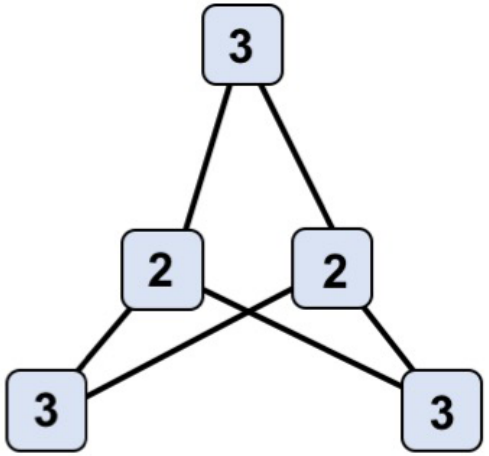


Figure 4. Participant Interface

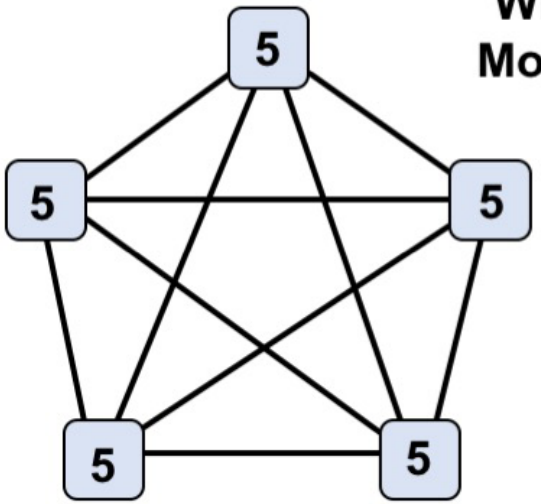




Wheel Network:
Monopoly Broker

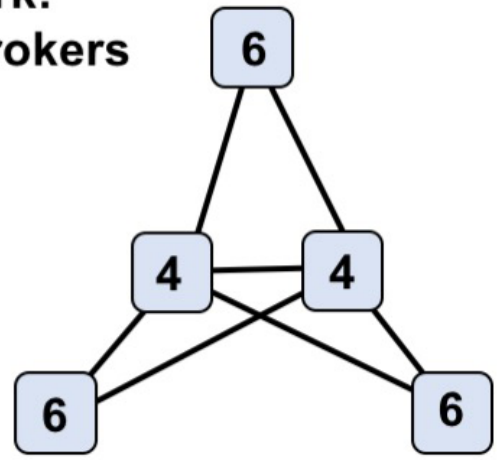


Mixed Network:
Disconnected Brokers



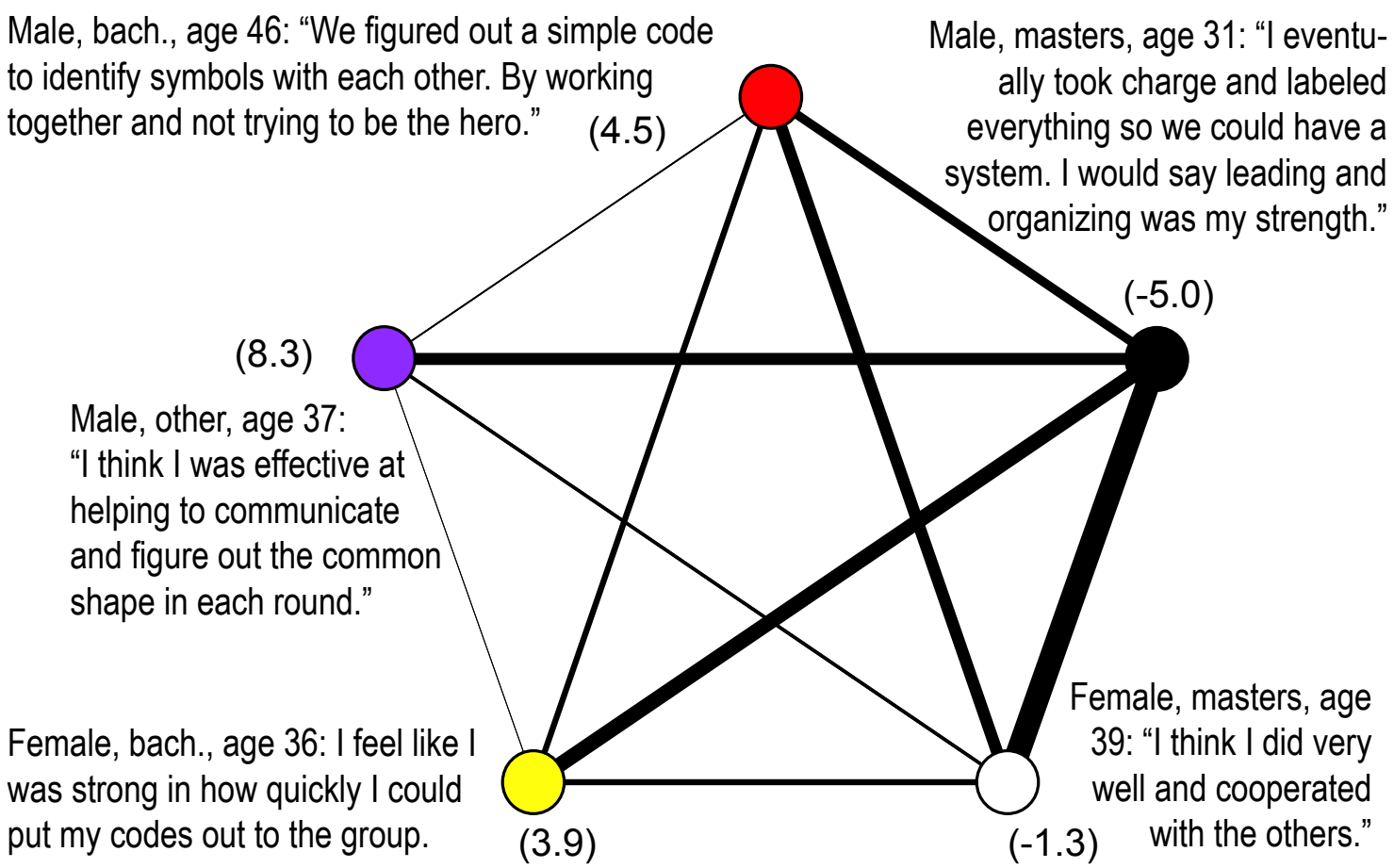
Clique Network:
No Broker

ID	Constraint	Position
1	25	6-hole broker
2	33	3-hole broker
3	50	1-hole broker
4	68	3-hole broker
5	77	5-person clique
6	100	3-person clique
7	100	pendant



Mixed Network:
Connected Brokers,
Overlapping Cliques

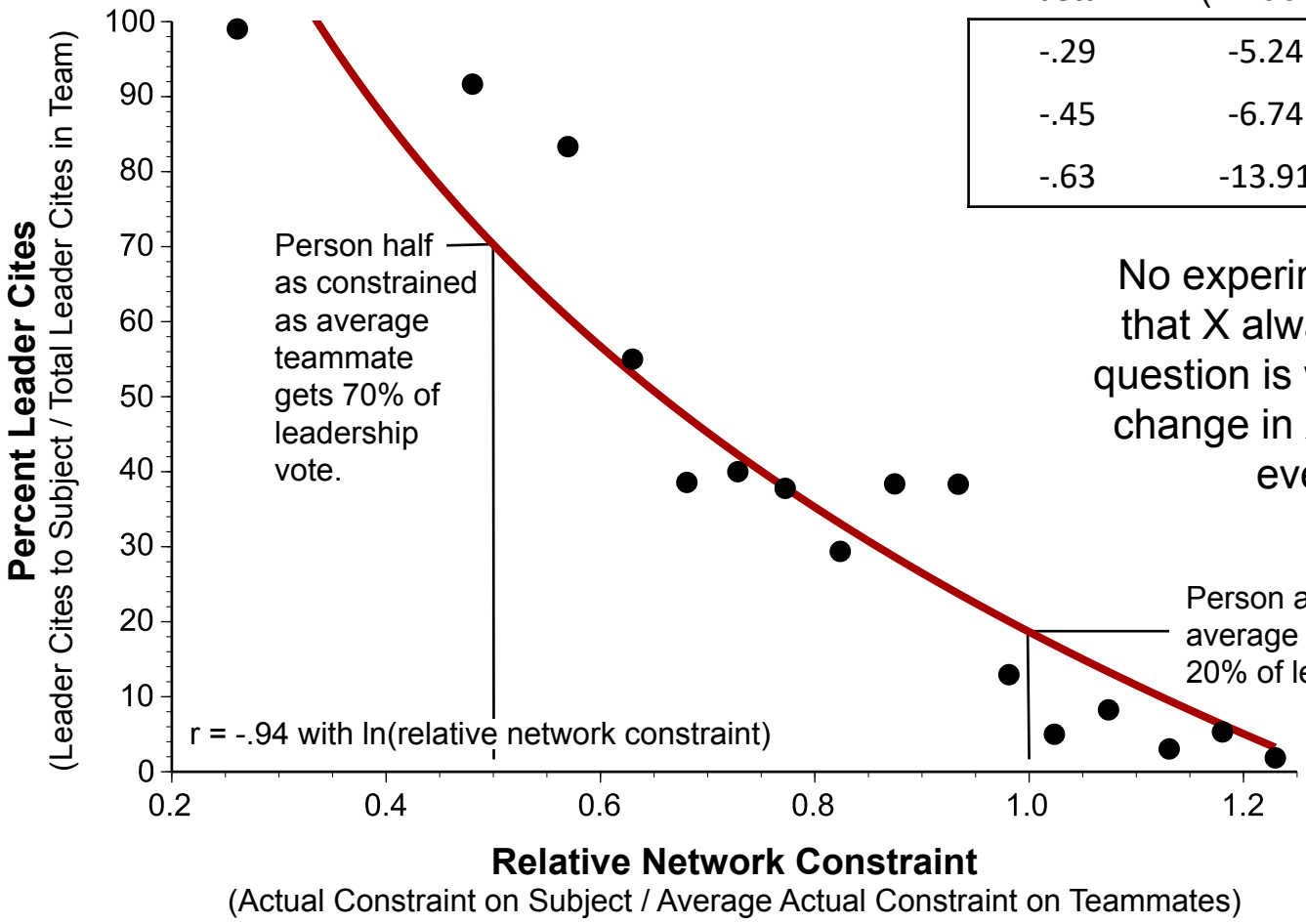
Figure 2. Four Treatment Networks



NOTE: Behavioral deviation scores in parentheses (behavioral constraint - treatment constraint). Quotes are responses to exit question: "How would you describe your strength in the game?" No quotes on abbreviated responses. Black dot receives all but one of the team leader citations. Other attributes are gender, education, and age.

Often, an Informal Network Leader Emerges to Help

(Figure 2 in Burt and Reagans, 2024 "Phantom Networks," Presented at Academy of Management meetings)



beta	t-test (N=385)	Network Constraint
-.29	-5.24	Treatment
-.45	-6.74	Behavioral
-.63	-13.91	Relative

No experiment can establish that X always causes Y. The question is whether exogenous change in X can be shown to ever cause Y.

In Fact, Even with Random Assignment to Networks, Network Brokers Are the People Perceived To Be Leaders

Burt, Reagans, and Volvovsky (*Social Networks*, 2021:Fig 10).

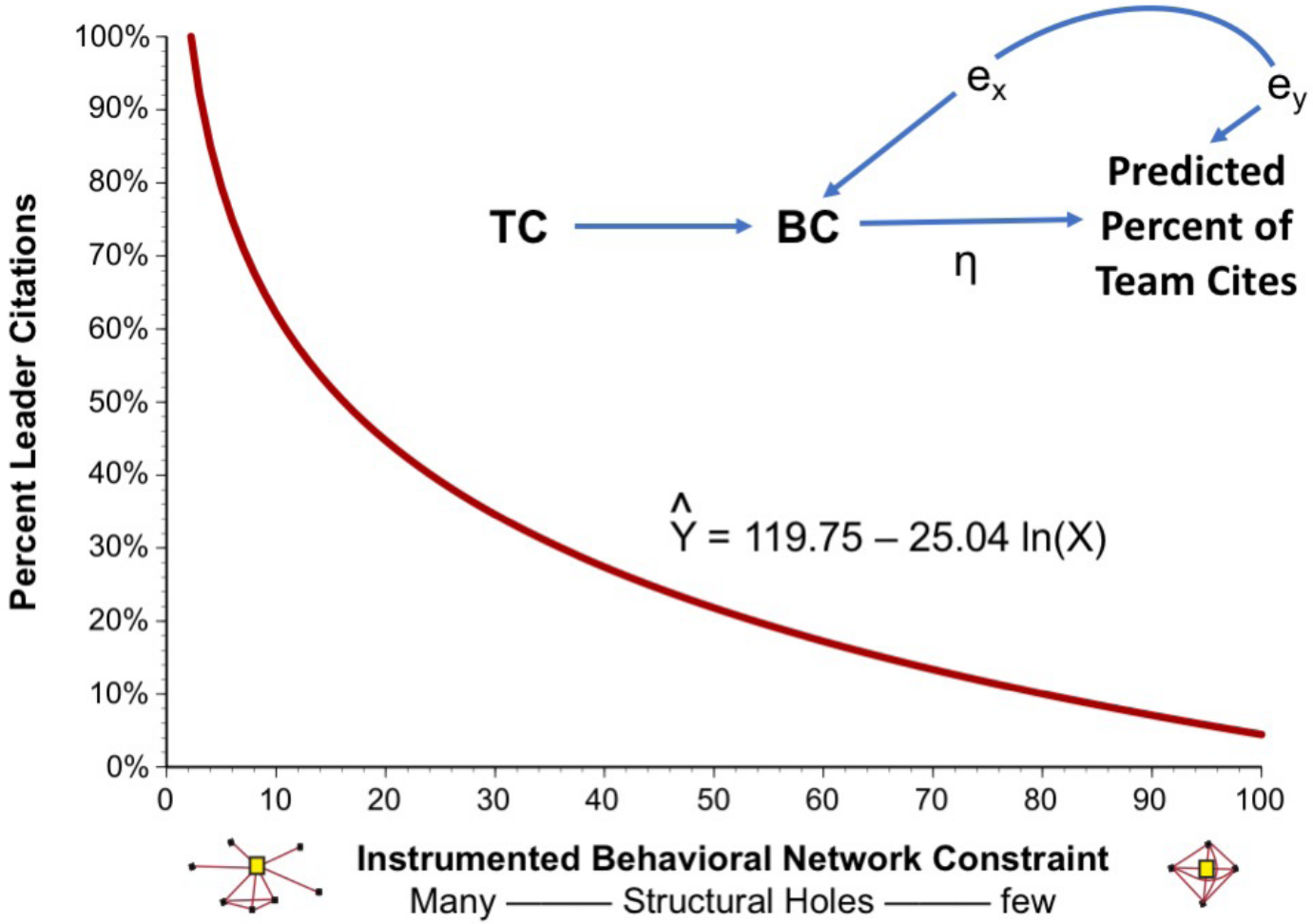


Figure 12.

Network Brokerage Triggers Citations for Team Leadership

Horizontal is level of constraint assigned at random to a person. Vertical is predicted percent of leader citations triggered by that level of constraint. Solid line is prediction across all assigned networks (lose 25.04% votes with unit increase in log constraint). Path diagram shows model used to estimate network effect, η, from log assigned treatment constraint (TC) as an instrument predicting log behavioral constraint (BC), with control variables included in e_y.

Table 3.
Estimates of Network Effect, η

	Coefficient η	(Robust S.E.)
Assigned Treatment Network	-23.47	(-5.15)
Behavioral Network	-28.18	(-6.39)
Instrumented Behavioral Network	-25.04	(-5.19)

Note: Estimates are for the network effect of the row predicting the percent of team leadership cites a subject receives. Network predictor is log network constraint. Percent cites is 100 times the ratio of leader cites received over leader cites available in a team. The ratio is set to zero for subjects who received zero cites regardless of how many cites were available in the team. Estimate in first row corresponds to Model A in Table 1. All three estimates include the controls in Model A (number of people eligible to cite participant, last active task, and ln constraint in the participant's network pre-experiment).

In other words (using the graph in Appendix III), an increase in network constraint from 15 to 40 points triggers a 25% decrease in team recognition of one's leadership.

Network Broker  Achievement

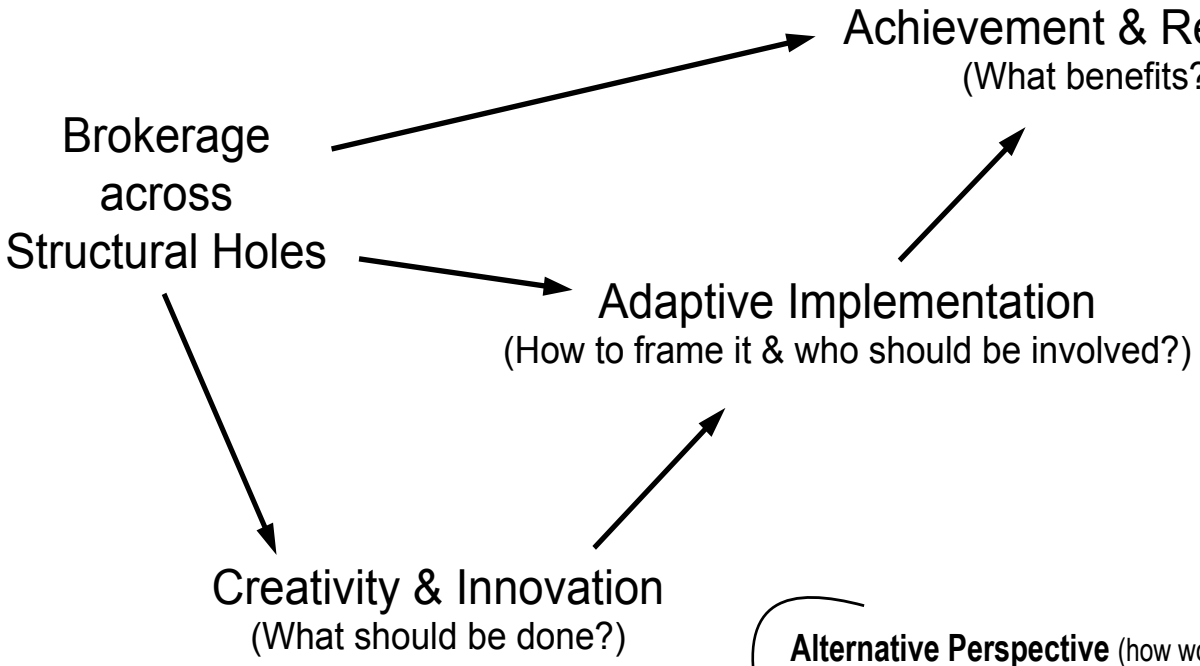
(Q289) Bridging structural holes can improve the odds of achievement, but achievement improves the odds of bridging structural holes. We cannot say that network structure is always causal for achievement, but given supportive evidence from experiments with random assignment to networks, we believe it can be causal. **True or False?**

A. True.

B. False.

HOW IT WORKS: Creativity and Innovation Are at the Heart of It

What in your work improves the odds that you will discover the value of something you don't know you don't know?



"She is proof that profound and generational party dominance in a state tends to yield mediocrity. Politicians from one-party states never learn broadness. They speak only Party Language to Party Folk. They aren't forced to develop policy mastery, only party dynamics. They rely on personal charm but are superficial. Going national requires developing more depth, or at least imitating depth. She didn't bother to do that." From Peggy Noonan's column *WSJ* 9/15/23.

Alternative Perspective (how would this problem look from the perspective of a different group, or groups — thinking "out of the box" is often less valuable than seeing the problem as it would look if you were inside a specific "other box")

Best Practice (something they think or do could be valuable in my operations)

Analogy (something about the way they think or behave has implications for how I can enhance the value of my operations; i.e., look for the value of juxtapositioning two clusters, not reasons why the two are different so as to be irrelevant to one another — you often find what you look for)

Synergy (resources in our separate operations can be combined to create a valuable new idea/practice/product)

from Burt, "The social capital of structural holes" (2002 *The New Economic Sociology*). The consequences of the information diversity associated with network brokerage is productively elaborated at length in economist Scott Page's 2007 book, *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools and Societies*.

Illustration: Where did the M-16 come from?

Discussion Question*

Consequential ideas are typically attributed to special people, geniuses, in part to make us feel less uncomfortable about our own ideas. True to form, an American armament expert describes Eugene Stoner, the engineer who developed the M-16 assault rifle, as "an engineering genius of the first order." Another describes him as "the most gifted small-arm designer since Browning." (Browning patented the widely-adopted BAR and 45 automatic.)

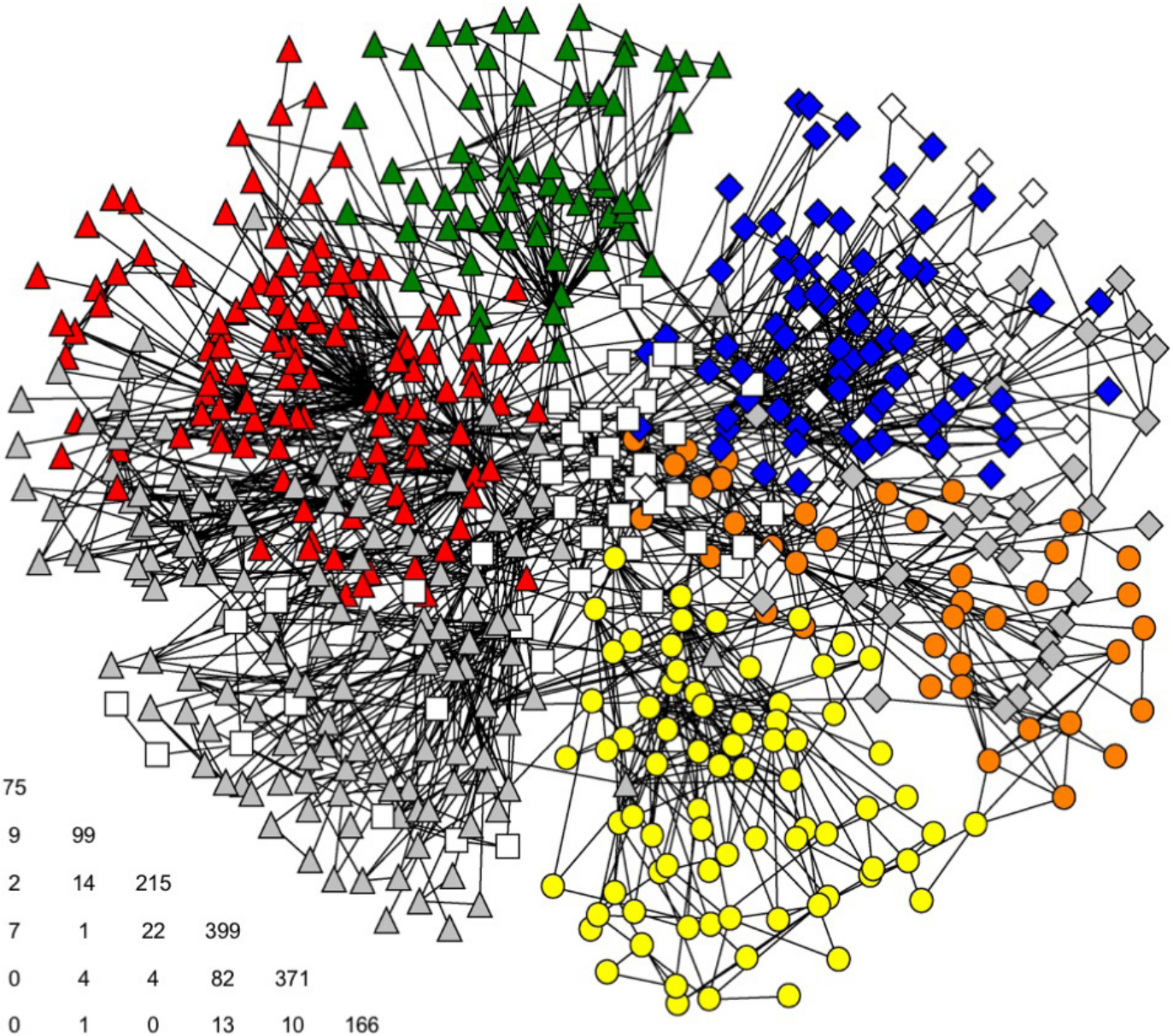
1. Based on the brief history video, how would you describe Stoner's genius?
2. What circumstances might allow you or your colleagues to be as creative?

*Photos are from the video shown during the session. For discussion and references, see page 73 in *Brokerage and Closure*. For sampling on the dependent variable, see Rosenzweig, "Misunderstanding the nature of company performance: the halo effect and other business delusions," 2007 *California Management Review*.

Sociogram of a Supply-Chain Management Network

Lines connect managers who often discuss their work with one another. Line counts are given in the table below.

Squares indicate managers at corporate headquarters. Triangles indicate managers in the largest division (Northern, Western, and Southwest sub-divisions). Diamonds are managers in the second largest division (Eastern sub-divisions). Circles are managers in two smaller divisions (Southeast and Southern).



Corp HQ	113								
Eastern 1	6	49							
Eastern 2	31	26	218						
Eastern 3	2	4	14	75					
Southeast	19	0	1	9	99				
Southern	19	1	1	2	14	215			
Southwest	29	2	8	7	1	22	399		
Western	29	2	6	0	4	4	82	371	
Northern	10	0	5	0	1	0	13	10	166

from Burt, *Neighbor Networks* (2010, p. 75)

Four Illustrative Idea Texts

(4.5 value, 20 network constraint, 122 words) — Reward program management for leveraging across the corporation. Poor ability to forecast program releases to the part number level. Accounting for program release cycles as we attempt to establish CWAs that span the Company. When it is time to handle the program release then time is too short to do all the necessary cross-BU activity that is required. Lack of recognition of the difference between the effort required to get even semi-sophisticated parts on CWA and with competing these items (versus obtaining COTS hardware) is associated with this problem. Also, having adequate resources is part of the problem. Policy change needs to involve the best people, people who wield influence, true commodity experts with practical experience on the largest programs.

(4.5 value, 22 network constraint, 114 words) — I believe that we are doing a lot of positive things to improve SCM across the Company (Professional Development, CMMI, e-tools, Supplier Rating System, etc.). However, our current organization structure inhibits us from leading the Industry in SCM effectiveness. Programs currently dictate our sources of supply. Therefore we are not able to fully leverage our Company buying power nor are we able to present that one Company voice to our suppliers. If SCM orgs reported directly to the Corporate VP of SCM, we would have more clout and be able to influence Enterprise decisions. At minimum, SCM orgs should report dual solid line to both Corp VP SCM and the BU General Manager.

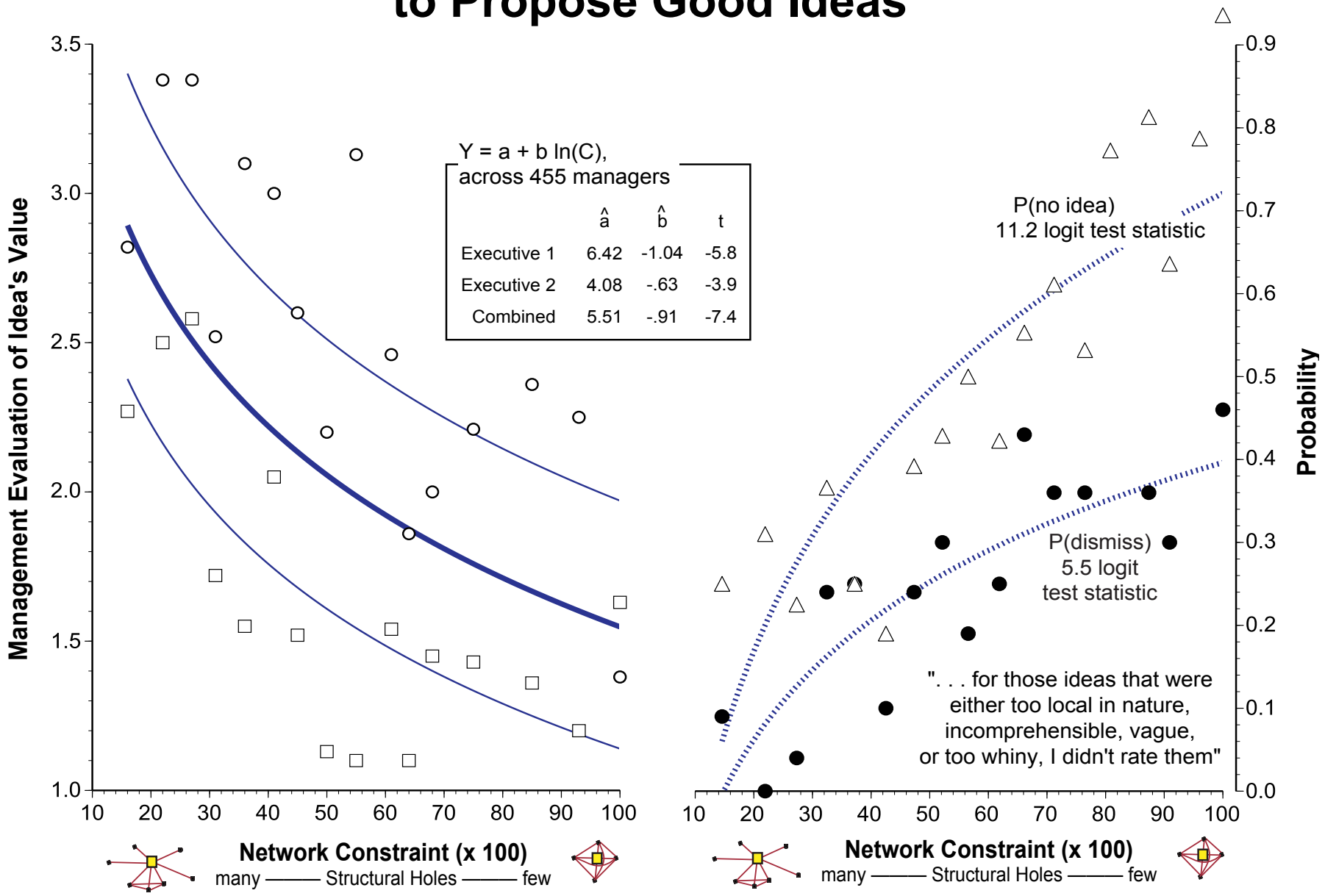
(1.5 value, 96 network constraint, 95 words) — Too much micromanagement! The cost-type development programs require cost-type subcontracts and COTS equipment. There ARE differences in development and integration that make it difficult to forecast beyond a few months relative to commitments, etc. We do not do fixed price production. The tools chosen by Corporate (i.e., Exostar and Freemarkets) are not useful at our location and don't really save money. Need to re-think the organization and divide into production vs development-type orgs. Too many bosses and too many requests for info from too many sources. Too many e-procurement initiatives.

(1.0 value, 100 network constraint, 102 words) — The number of new hires in SCM is growing at a rapid rate, specifically Buyers and Planners. There are currently four working Managers overseeing approximately 90 Staff. Working Managers have broad responsibilities over and above supporting their Staff. Therefore, the Staff does not get the direction nor support needed to excel and improve processes. Recommendation of Change: (1) Relieve managers that oversee large staffs from other responsibilities so that they can manage their staff, or (2) Add more senior managers so that the staffs are smaller, or (3) Put in place a second line of supervision that can direct and support the staff.

NOTE — Word count is from LIWC. BU stands for business unit. CMMI stands for Capability Maturity Model Integration. “Company” stands for the name of the firm. COTS stands for products available commercially off the shelf. CWA stands for CEN Workshop Agreement, which is a consensus-based specification. Exostar and Freemarkets are commercial products for supply-chain management. SCM stands for supply-chain management or supply-chain manager.

The 455 idea data from this study population are discussed with examples in *Brokerage & Closure*, pages 66-69.

Network Brokers Are More Likely to Propose Good Ideas



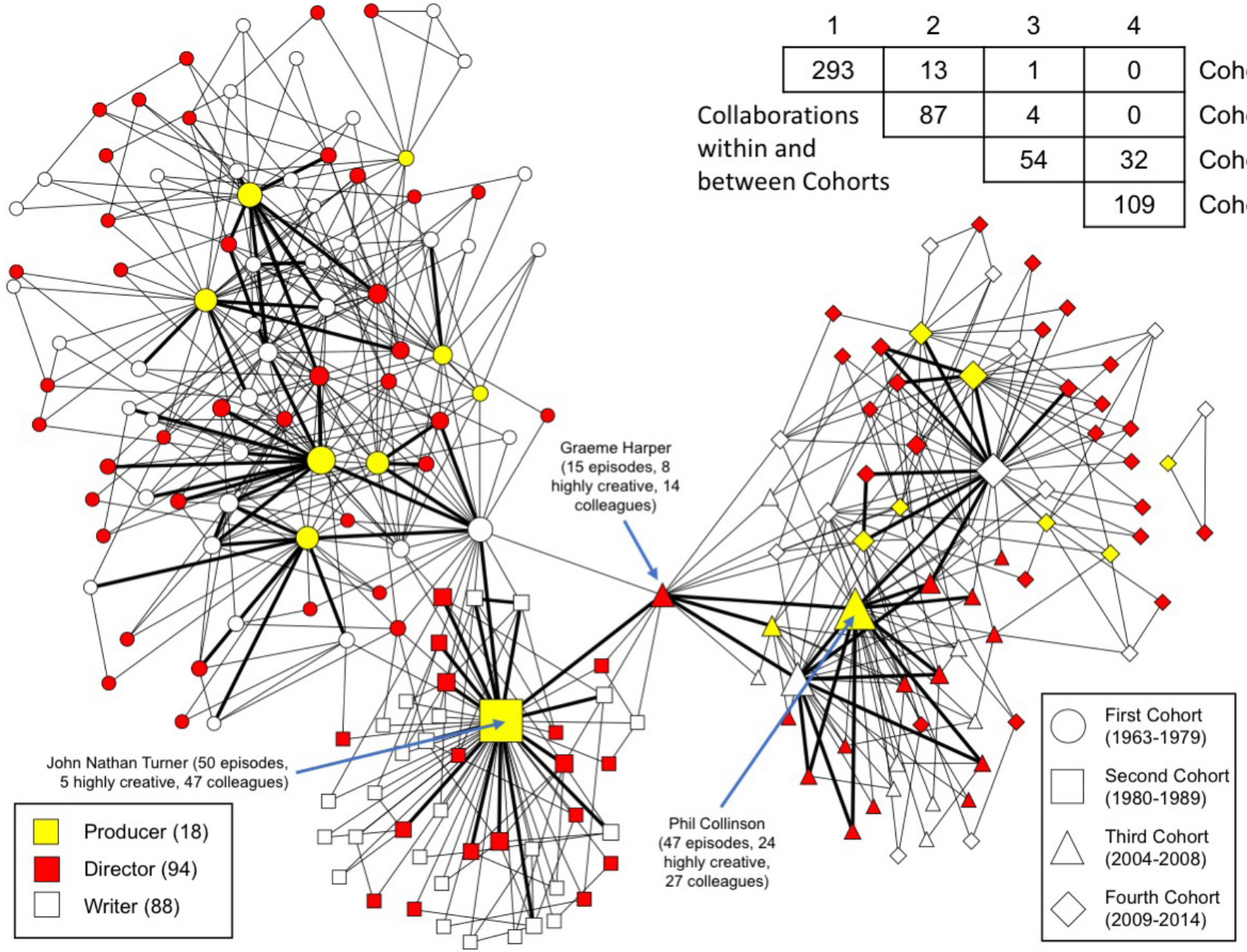
from Figure 2.1 in *Brokerage and Closure* (or Figure 5 in Burt, "Structural holes and good ideas," 2004 *American Journal of Sociology*, point is elaborated in Burt and Soda, "The social origins of great strategies," 2017 *Strategy Science*).

Network Brokers Use More Familiar Words

	Network Brokers: Relatively Open Networks (n = 146)	Average Networks (n = 157)	Clique Managers: Relatively Closed Networks (n = 152)	Probability No Difference
Outstanding Idea	23.3%	4.5%	5.3%	P < .001
Idea Dismissed	14.4%	36.9%	43.4%	P < .001
Familiar Words	56.3	46.7	34.3	P < .001

NOTE — Columns distinguish the bottom, middle, and top third of 455 managers on network constraint. The three columns (-1, 0, 1) predict the row variables. “Outstanding idea” is percent of managers whose idea received the maximum rating from either judge (49 of 455 ideas). Probability test is based on a -4.76 z-score test statistic in a logit regression model. “Idea Dismissed” is the percent of managers whose idea is dismissed by either judge as not worth rating (145 of 455 ideas). Probability test is based on a 5.14 z-score in a logit regression model. “Familiar Text” is the number of words in a manager’s text that are familiar in the sense that they are found in the LIWC language software dictionary. Probability test is based on a -9.49 z-score in a Poisson regression model. All three predictions include a control for the number of words in a manager’s idea text.

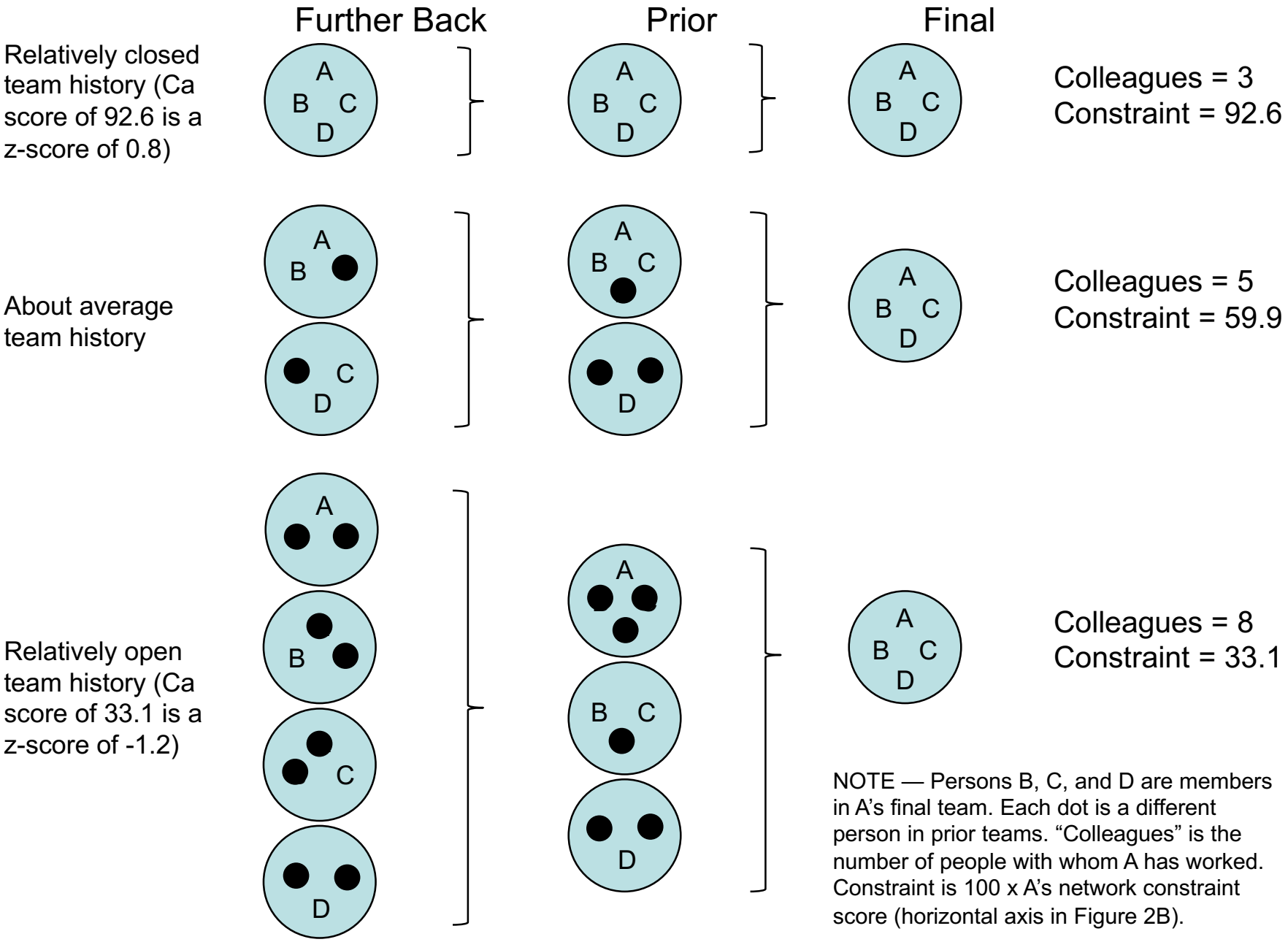
Adapted fromTable 1 in Burt, "Social network and creativity" (*Handbook of Research on Creativity and Innovation*, 2020). For more general results on broker advantage depending on brokers using familiar language, see Goldberg, Srivastava, et al., "Fitting in or standing out?" (2016, *American Sociological Review*)



The *Doctor Who* Production World

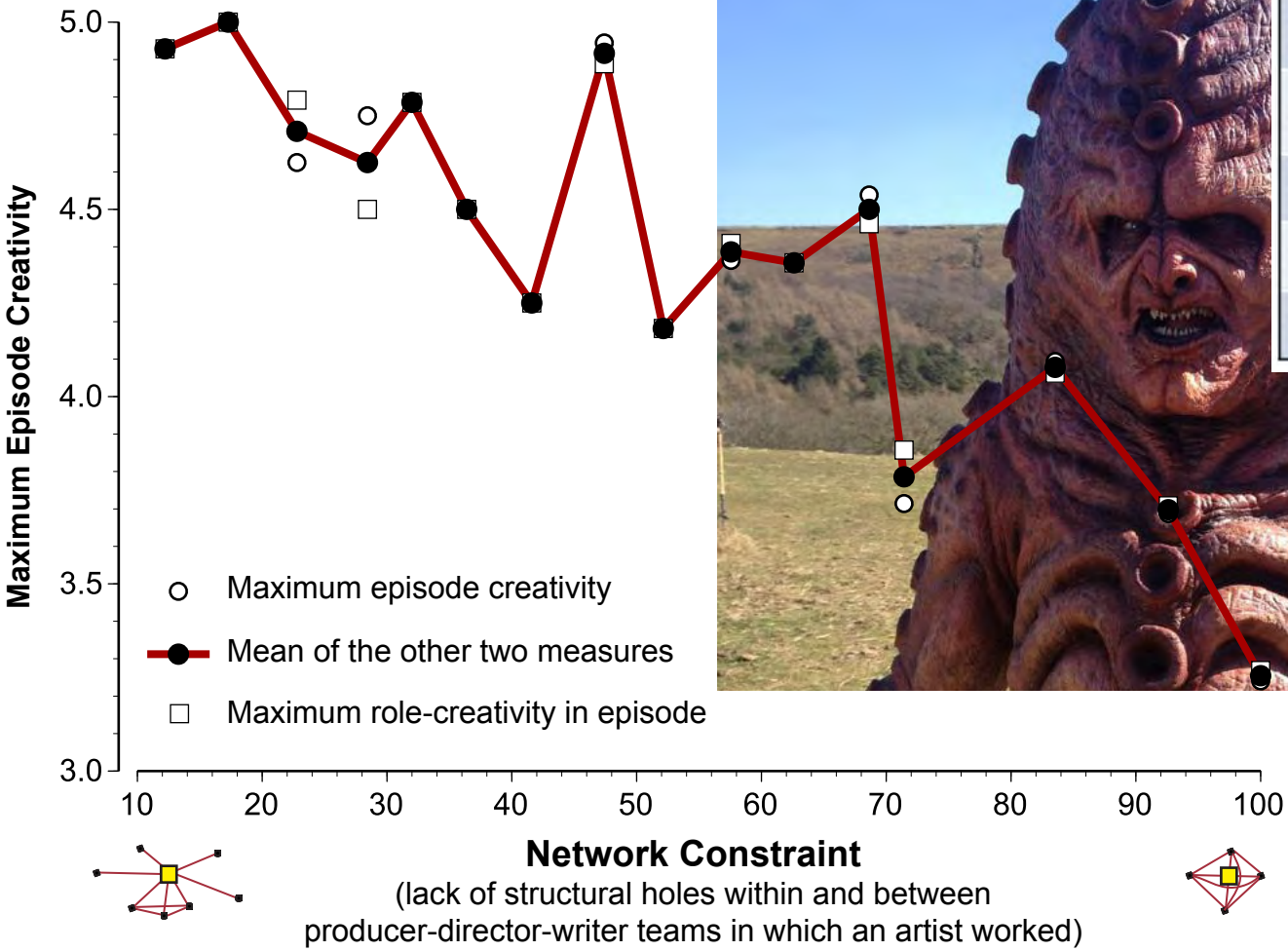
These are the 593 connections among the 200 producers, directors, and writers,1963 to 2014 (from Soda, Mannucci, Burt, 2021, AMJ). Lines connect people who worked on the same episode. Bold lines connect people who worked on two or more episodes together. Larger symbols indicate people on more episodes.

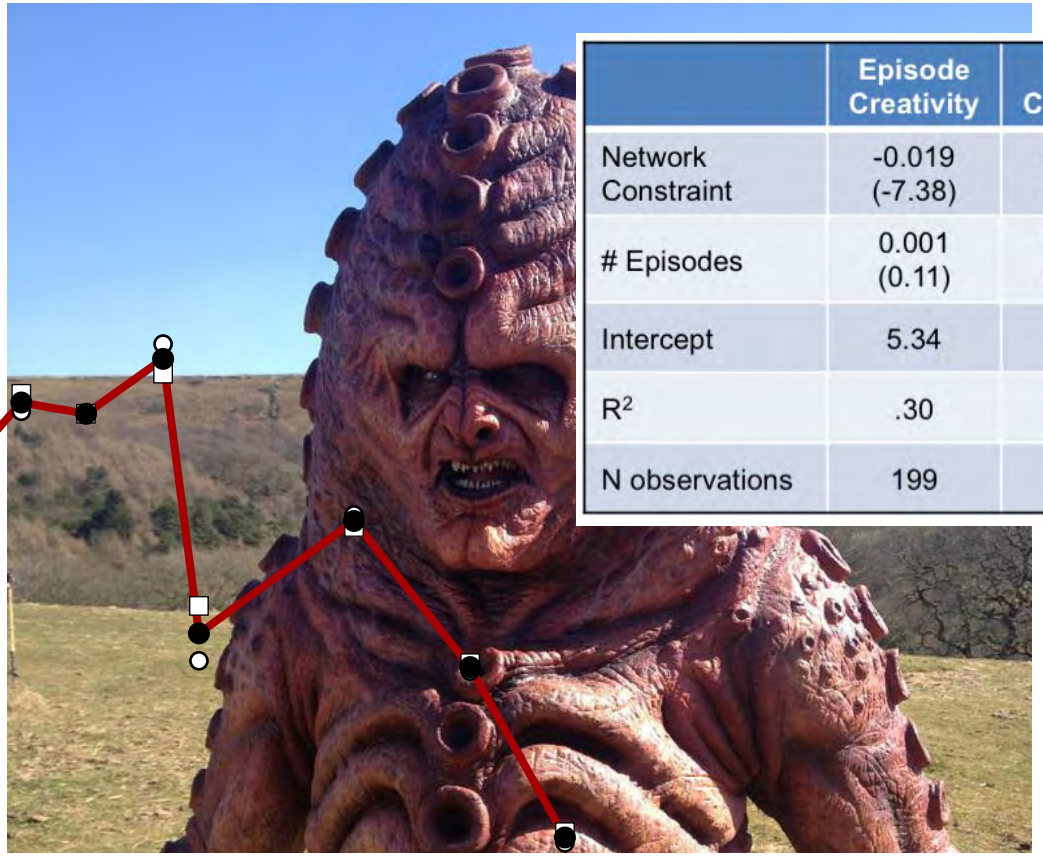
Three Team Histories for Person A



NOTE — Persons B, C, and D are members in A's final team. Each dot is a different person in prior teams. "Colleagues" is the number of people with whom A has worked. Constraint is 100 x A's network constraint score (horizontal axis in Figure 2B).

Figure 3 in Burt, "Social network and creativity" (*Handbook of Research on Creativity and Innovation*, 2021).

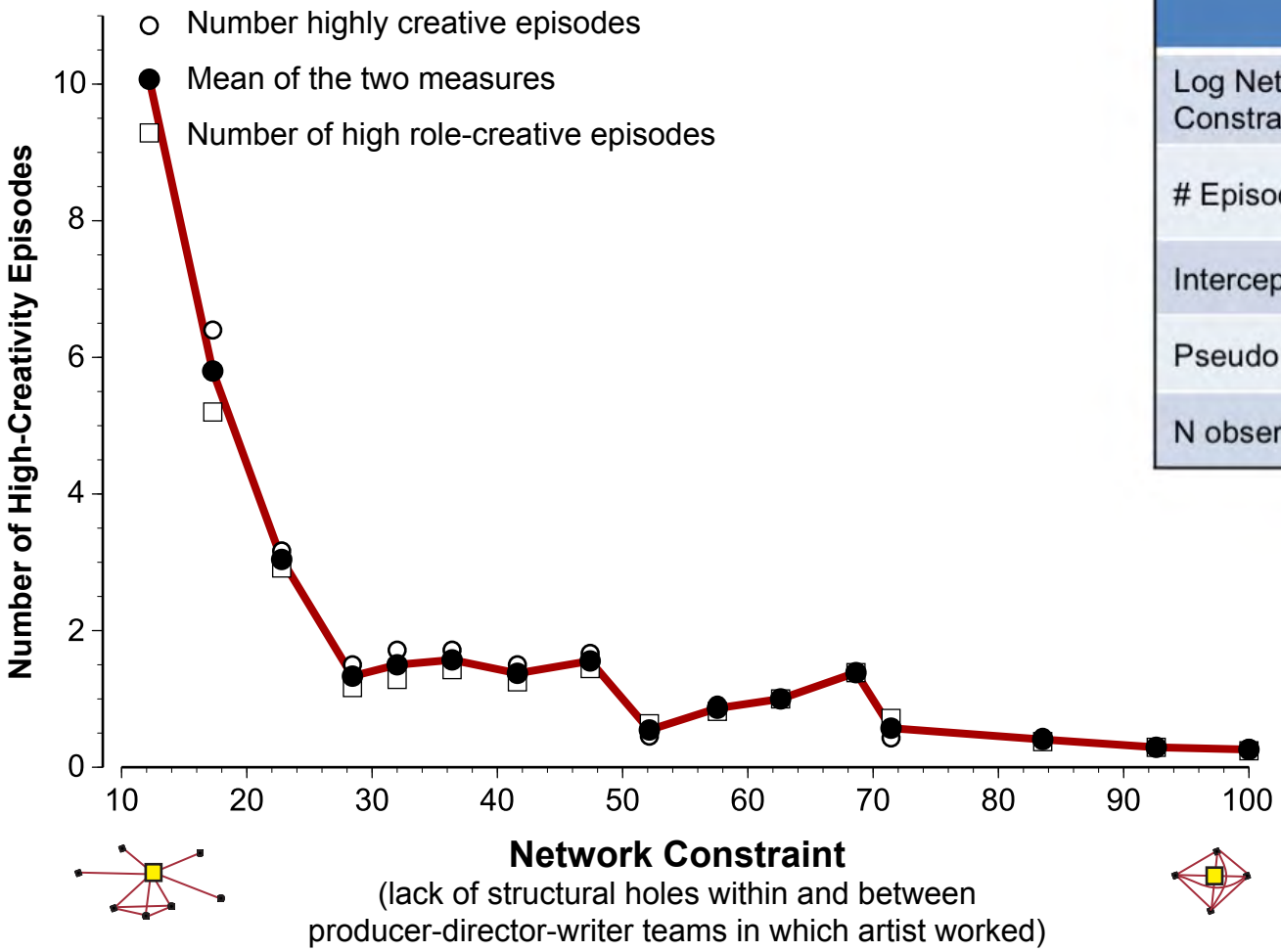




	Episode Creativity	Role Creativity
Network Constraint	-0.019 (-7.38)	-0.019 (-6.96)
# Episodes	0.001 (0.11)	0.002 (0.35)
Intercept	5.34	5.32
R^2	.30	.29
N observations	199	199

Greatest Creativity Decreases as Network Closes

Graph is from Soda, Mannucci, and Burt (2021, *Academy of Management Journal*). Creativity scores for the producers, directors, and writers are averaged within five-point intervals of network constraint (two intervals containing only one individual are combined with the closest adjacent interval). Creativity is measured by the highest creativity rating an artist ever received for his or her role on an episode (square), and the highest rating ever received by an episode on which he or she worked (circle). Solid dots are the average of the episode and role creativity averages.Test statistics are given in parentheses and outlier producer John Nathan Turner is excluded from the prediction. Picture is an evil alien (Zygon) in the series.



	Episode Creativity	Role Creativity
Log Network Constraint	-1.115 (-6.98)	-0.917 (-5.17)
# Episodes	0.041 (4.94)	0.051 (6.79)
Intercept	4.16	3.24
Pseudo R^2	.45	.42
N observations	199	199

Career Creativity Decreases as Network Closes

Graph is from Soda, Mannucci, and Burt (2021). Creativity scores for the 200 producers, directors, and writers are averaged within five-point intervals of network constraint (two intervals containing only one individual are combined with the closest adjacent interval). Creativity is measured by the total number of an artist's episodes given a maximum creativity rating by either judge for the episode (circle) or the artist's role on the episode (square). Solid dots are the average of the episode and role creativity averages. Test statistics are given in parentheses and outlier producer John Nathan Turner is excluded from the prediction.

Two Summary Points

Network Structure Is a Proxy for the Distribution of Information

For reasons of opportunity, shared interests, experience, a division of labor; organizations and markets drift toward the bridge-and-cluster structure responsible for Milgram's “small world” phenomenon.

Anchor Effect #1, Network Advantage: Brokers Do Better

Bridge relations across the structural holes between clusters provide information breadth, timing, and arbitrage advantages, such that network brokers managing the bridges are at higher risk of “productive accident” in detecting and developing good ideas. Engaging that higher risk is energizing, an incentive in its own right for acts of brokerage. By clearing the sticky-information market across organizations, brokers tend to be recognized leaders, better compensated than peers, more widely celebrated than peers, and promoted to leadership more quickly than peers. Creativity and innovation specifics:

- Closed networks do not identify unintelligent managers so much as specialists.

- Creativity is an import/export process. Value is not at the innovation source. It emerges each time productive new knowledge is adopted in a target audience. In this, creativity and good ideas are a by-product of network brokerage operating. "To feel creative, find someone more ignorant than you."

- Creativity depends on the network as well as individual ability. It does not depend on individual genius so much as it depends on finding opportunities to broker knowledge from where it is routine to where it would create value. In this, creativity and good ideas reflect how people are organized as well as their individual abilities.

(Q203) Closed networks do not identify unintelligent managers so much as they identify specialists. **True or false?**

A. True

B. False

(Q262) Network brokers are more likely to propose creative, innovative ideas that appeal to top management. One reason for the appeal of broker proposals is the creative, innovative language brokers use. **True or false?**

A. True

B. False

(Q83) Returns to brokerage depend on senior management recognizing the importance of social networks for employee performance. **True or false?**

A. True

B. False

(Q130) We discussed creativity/innovation as an import-export game that does not require genius. **Which of the below is most responsible for the truth of the statement?**

A. A person can be lucky whether or not she is a genius.

B. Genius is a word the ignorant use to describe competent.

C. To be seen as creative, find people more ignorant than yourself.

D. Idea value resides in the audience.

E. Idea value resides in the inventor.

(Q261) Information and ways of understanding are more homogeneous within than between social clusters. Being able to see the boundaries between social clusters is therefore critical to identifying the structural holes that define rewarding opportunities for brokerage. Fortunately, **(circle best completion to the sentence)**:

A. the boundaries around social clusters are sharply defined by the absence of connections between clusters.

B. the boundaries around social clusters are often ambiguous but can be identified by the absence of connections between clusters relative to presence within clusters.

C. the boundaries around social clusters are often ambiguous so we define them by talking with people in each cluster to learn whether opinion and practice in one cluster differs from opinion or practice in the other cluster.

D. successful network brokers can ignore boundaries.

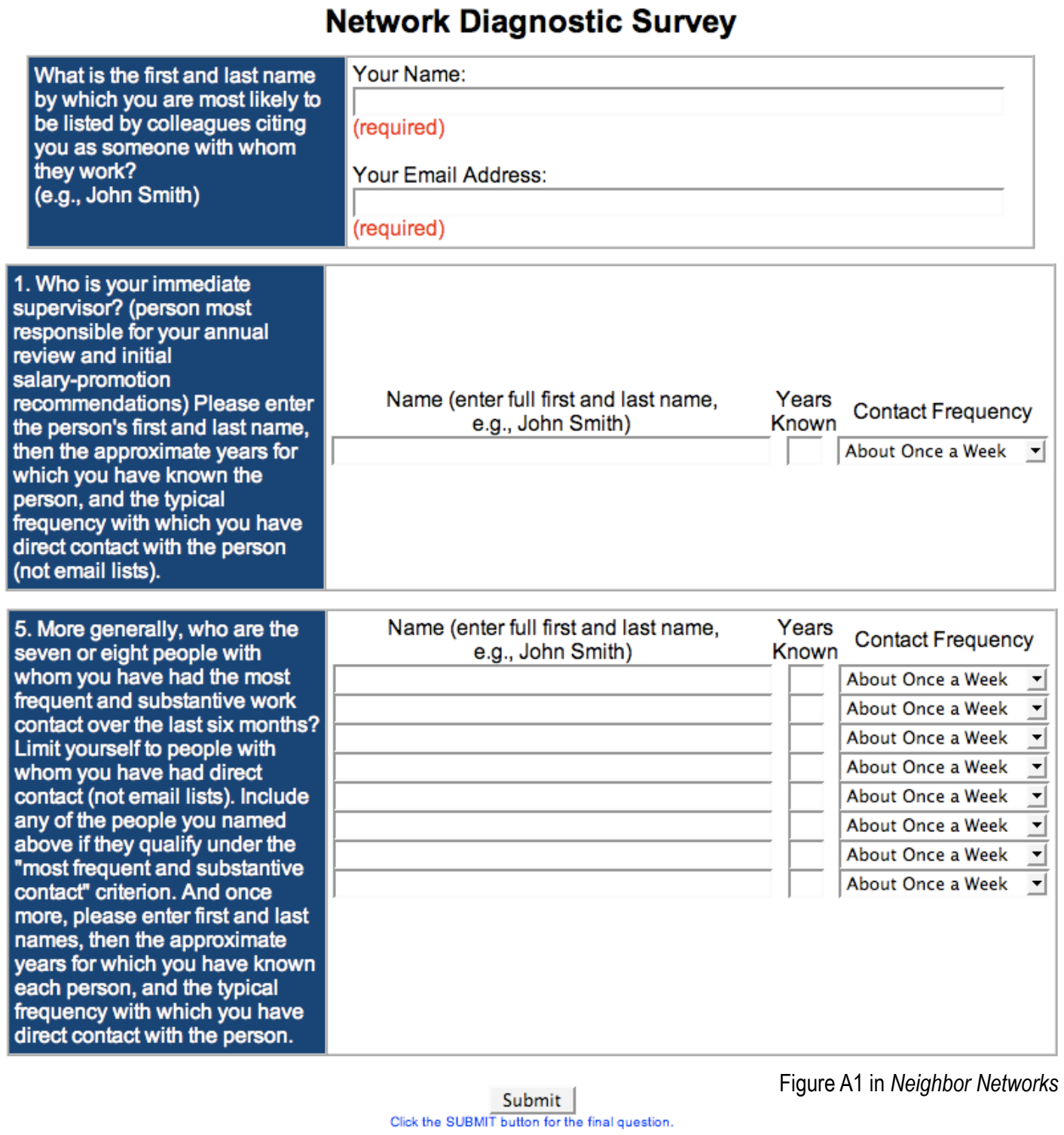
Appendix
Materials

Appendix I:

Example Network Questionnaire for a Web Survey

for discussion of these slides and how to collect network data, see Appendix A, "Measuring the Network," in *Neighbor Networks*.

For a similar offline exercise, see Hermi Ibarra's 2008 network exercise on the HBSP website (item 9-497-993).



Network Diagnostic Survey

What is the first and last name by which you are most likely to be listed by colleagues citing you as someone with whom they work? (e.g., John Smith)

Your Name:
(required)

Your Email Address:
(required)

1. Who is your immediate supervisor? (person most responsible for your annual review and initial salary-promotion recommendations) Please enter the person's first and last name, then the approximate years for which you have known the person, and the typical frequency with which you have direct contact with the person (not email lists).

Name (enter full first and last name, e.g., John Smith)	Years Known	Contact Frequency
		About Once a Week

5. More generally, who are the seven or eight people with whom you have had the most frequent and substantive work contact over the last six months? Limit yourself to people with whom you have had direct contact (not email lists). Include any of the people you named above if they qualify under the "most frequent and substantive contact" criterion. And once more, please enter first and last names, then the approximate years for which you have known each person, and the typical frequency with which you have direct contact with the person.

Name (enter full first and last name, e.g., John Smith)	Years Known	Contact Frequency
		About Once a Week
		About Once a Week
		About Once a Week
		About Once a Week
		About Once a Week
		About Once a Week
		About Once a Week
		About Once a Week

Submit

Click the SUBMIT button for the final question.

Figure A1 in *Neighbor Networks*

Appendix I, continued

Network Diagnostic Survey

5. This final question asks for your view of connections among the people you named. Please don't quit here. You are almost finished. The people you cited in the previous page are listed in the table below. The task is to select a letter indicating your view of the connection between each pair of people, where

"Often" means that, to your knowledge, the two people speak often with one another such that they are probably familiar with current issues in one another's operations.

"Some" indicates that you know only that the two people sometimes talk to one another, such that they have some familiarity with current issues in one another's operations.

"Rare" indicates, again as best you know, that the two people speak infrequently or not at all to one another.

"Difficult" indicates that, for reasons that could be no fault of either person, there has been difficulty in coordinating work between the two people.

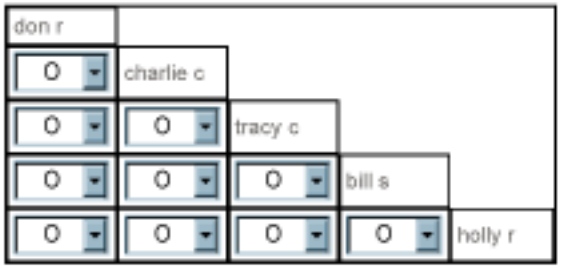
For example, if you named three people (Jose, John, and Jody) who speak often with one another and haven't had difficulty coordinating their work when they should, the table would look like this:

Jose A		
O	John S	
O	O	Jody Y

If you named four people (Jose, John, Jody, and Wen) where Jose and Jody are closely connected, Jose and John have had difficulty coordinating their work, and the others rarely speak to one another, the table would look like this:

Jose K			
D	John S		
O	R	Jody Y	
R	R	R	Wen Q

HERE IS THE TABLE WITH NAMES OF YOUR CONTACTS ON THE DIAGONAL. People are listed with the default that they speak often. **USE THE PULL-DOWN MENUS IN THE CELLS TO INDICATE YOUR VIEW OF THE CONNECTION BETWEEN EACH PAIR OF PEOPLE.** If you wish to change or add names, hit your browser's "BACK" button, edit your citations on the previous page, and return here to describe the network.



Click the SUBMIT button to save all your data.

Figure A2 in *Neighbor Networks*

(Appendix I, cont.) Business Event Name Generator

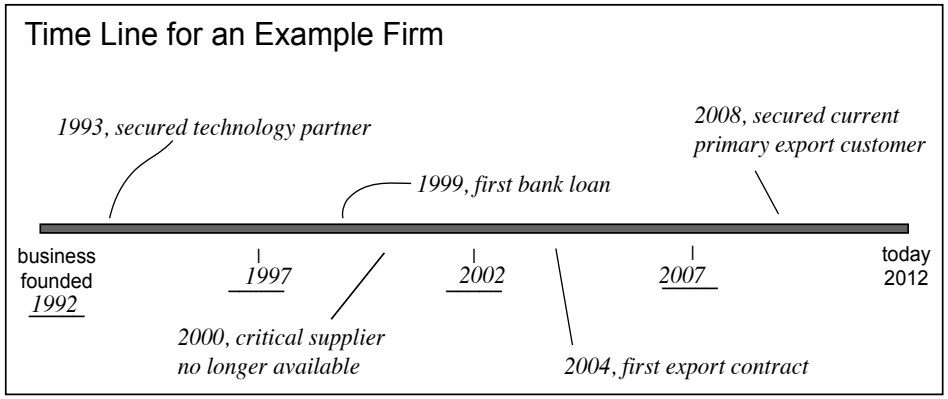
The next five questions generate a summary picture of the business network. To draw the picture, you will be asked about people, but we do not want to know any one's name. I will go through this network worksheet with you, asking about people who were useful to your business in one way or another. Without mentioning anyone's name to me, please write on your worksheet the names of people who come to mind in response to the questions. We will create a list of names then refer to people by their order on the list. No names. You will keep the worksheet to yourself.

Q1. Let me begin with an example so you can see how the interview protects your confidentiality at the same time that a picture of the business network emerges. Your business time line shows that your firm was founded in _(say founding year)_. **Please think back to your activities in founding the firm. Who was the one person who was most valuable to you in founding the firm?**

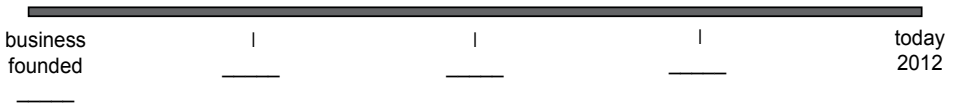
Confidential

Business Time Line Worksheet

Time Line for an Example Firm



Time Line for Your Firm



Q2. Now please do the same thing for each of the significant events you listed on your business time line. The first significant event you listed was __(say first event)__ in _(say year)_. **Who was the person most valuable to you during that event?** Please write on the first line below the person's name. The person most valuable in this event could be the same person who was most valuable to you in founding the firm. You would just enter the name again.

from Burt and Burzynska, "Chinese entrepreneurs, social networks, and *guanxi*" (2018 *Management and Organization Review*)

(App. I, cont.) Name Interpreters Flesh Out Relationships and Define Connections among Cited Contacts

- Contact Gender (male, female)
- Emotional Closeness to Contact (especially close, close, less close, distant)
- Duration of Connection with Contact (years known)
- Frequency of Contact (daily, weekly, monthly, less often)
- Trust (1 to 5, low to high trust) "Consider the extent to which you trust each of the listed people. For example, suppose one of the people asked for your help. The help is not extreme, but it is substantial. It is a level of help you cannot offer to many people. To what extent would you trust each person to give you all the information you need to decide on the help? For example, if the person was asking for a loan, would they fully inform you about the risks of them being able to repay the loan? If the person was asking you give a job to one of their relatives, would they fully inform you about their relative's poor work attitude or weak abilities, or other qualities that would make you prefer not to hire the relative?"
- Role (all that apply: family, extended family, neighbor, party, childhood, classmate, military, colleague, business association)
- Matrix of Connections between Contacts (especially close, distant, or something in between)

from Burt and Burzynska, "Chinese entrepreneurs, social networks, and *guanxi*" (2017 *Management and Organization Review*)

Appendix II: Measuring Access to Structural Holes*

from Burt, "Formalizing the argument," (1992, *Structural Holes*); "Gender of social capital" (1998, *Rationality and Society*); Appendix B "Measuring Access to Structural Holes," (2010, *Neighbor Networks*). See the Jeff Pfeffer Stanford case #OB-66 for a productive overview ("A note on networks and network structure").

Network brokerage is typically measured in terms of opportunities to connect people. When everyone you know is connected with one another, you have no opportunities to connect people. When you know a lot of people disconnected from one another, then you have a lot of opportunities to connect people. "Opportunities" should be emphasized in these sentences. None of the usual brokerage measures actually measures brokerage behavior. They index opportunities for brokerage. Reliability and cost underlie the practice of measuring brokerage in terms of opportunities. It is difficult to know whether or not you acted on a brokerage opportunity. One can know with more reliability whether or not you had an opportunity for brokerage. Acts of brokerage could be studied with ethnographic data, but the needed depth of data would be expensive, if not impossible, to obtain by the practical survey methods used to measure networks.

Good reasons notwithstanding, the practice of measuring brokerage by its opportunities rather than its occurrence means that performance has uneven variance across levels of brokerage opportunities. Performance is typically low in the absence of opportunities. Performance varies widely where there are many opportunities: (1) because some people with opportunities do not act upon them and so show no performance benefit, (2) because it is not always valuable to move information between disconnected people (e.g., explain to your grandmother the latest technology in your line of work), or (3) because the performance benefit of brokerage can occur with just one key bridge relationship. A sociologist might do more creative work because of working through an idea with a colleague from economics, but that does not mean that she would be three times more creative if she also worked through the idea with a colleague from psychology, another from anthropology, and another from history. The above three points can be true of brokerage measured in terms of action, but under the assumption that people invest less in brokerage that adds no value, the three points are more obviously true of brokerage measured in terms of opportunities. It could be argued that people more often involved in bridge relations are more likely to have one bridge that is valuable for brokerage, and to understand how to use bridges to add value, but the point remains that the network measures discussed below index opportunities for brokerage, not acts of brokerage.

Bridge Counts

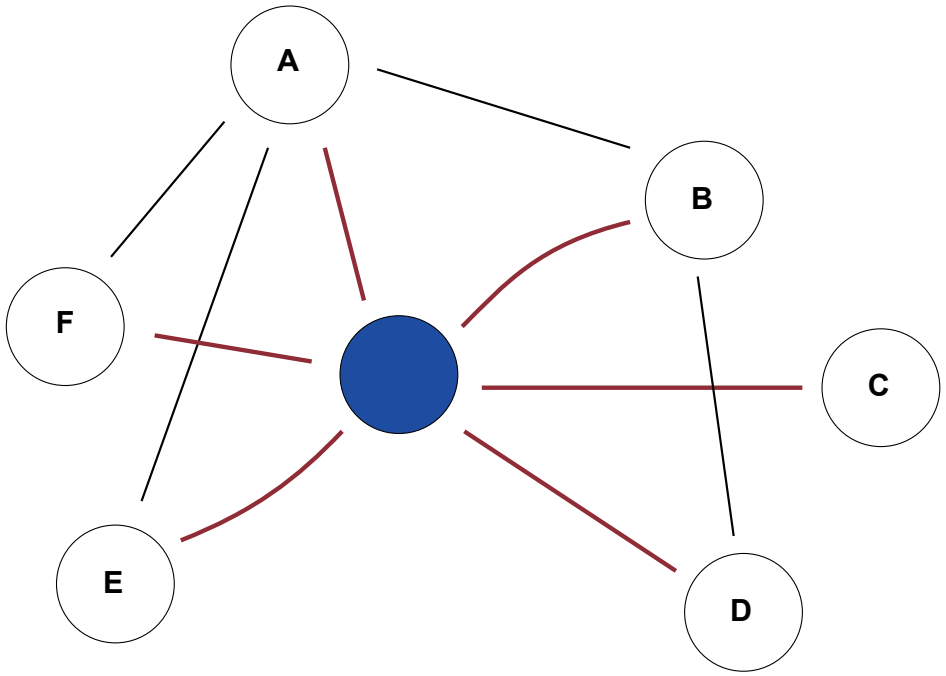
Bridge counts are an intuitively appealing measure. The relation between two people is a bridge if there are no indirect connections between the two people through mutual contacts. Associations with performance have been reported measuring brokerage with a count of bridges (e.g., Burt, Hogarth, and Michaud, 2000:Appendix; Burt, 2002).

Constraint

I measure brokerage opportunities with a summary index, network constraint. As illustrated on the next page, network constraint begins with the extent to which manager i's network is directly or indirectly invested in the manager's relationship with contact j (Burt 1992: Chap. 2): $c_{ij} = (p_{ij} + \Sigma_q p_{iq} p_{qj})^2$, for $q \neq i,j$, where p_{ij} is the proportion of i's network time and energy invested in contact

Illustrative Network and Computation

Constraint measures the extent to which a network doesn't span structural holes



Network constraint measures the extent to which your network time and energy is concentrated in a single group. There are two components: (direct) a contact consumes a large proportion of your network time and energy, and (indirect) a contact controls other people who consume a large proportion of your network time and energy. The proportion of i's network time and energy allocated to j, p_{ij}, is the ratio of z_{ij} to the sum of i's relations, where z_{ij} is the strength of connection between i and j, here simplified to zero versus one.

$$c_{ij} = (p_{ij} + \Sigma_q\, p_{iq}p_{qj})^2 \quad q \neq i,j$$

contact-specific constraint (x100):

A	15.1
B	8.5
C	2.8
D	4.9
E	4.3
F	4.3
total	39.9

100(1/36)

= aggregate constraint ($C = \Sigma_j\, c_{ij}$)

network data

A	.	1	0	0	1	1	1
B	1	.	0	1	0	0	1
C	0	0	.	0	0	0	1
D	0	1	0	.	0	0	1
E	1	0	0	0	.	0	1
F	1	0	0	0	0	.	1
gray dot	1	1	1	1	1	1	.

Figure 2.2 in *Structural Holes*.

j, $p_{ij} = z_{ij} / \Sigma_q z_{iq}$, and variable z_{ij} measures the strength of connection between contacts i and j. Connection z_{ij} measures the lack of a structural hole so it is made symmetric before computing p_{ij} in that a hole between i and j is unlikely to the extent that either i or j feels that they spend a lot of time in the relationship (strength of connection "between" i and j versus strength of connection "from" i to j; see Burt, 1992:51). The total in parentheses is the proportion of i's relations that are directly or indirectly invested in connection with contact j. The sum of squared proportions, $\Sigma_j c_{ij}$, is the network constraint index C. I multiply scores by 100 to discuss integer levels of constraint.

The network constraint index varies with three network dimensions: size, density, and hierarchy. Constraint on a person is high if the person has few contacts (small network) and those contacts are strongly connected to one another, either directly (as in a dense network), or through a central, mutual contact (as in a hierarchical network). The index, C, can be written as the sum of three variables: $\Sigma_j(p_{ij})^2 + 2\Sigma_j p_{ij}(\Sigma_q p_{iq} p_{qj}) + \Sigma_j(\Sigma_q p_{iq} p_{qj})^2$. The first term in the expression, C-size in Burt (1998), is a Herfindahl index measuring the extent to which manager i's relations are concentrated in a single contact. The second term, C-density in Burt (1998), is an interaction between strong ties and density in the sense that it increases with the extent to which manager i's strongest relations are with contacts strongly tied to the other contacts. The third term, C-hierarchy in Burt (1998), measures the extent to which manager i's contacts concentrate their relations in one central contact. See Burt (1992:50ff.; 1998:Appendix), Borgatti, Jones, and Everett (1998), Everett and Borgatti (2020) for discussion of components in network constraint.

Size

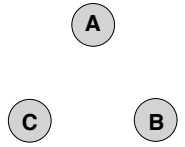
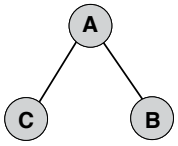
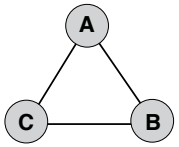
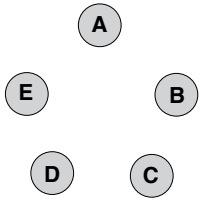
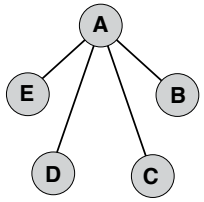
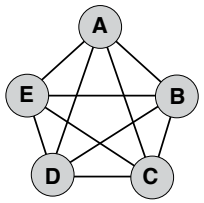
Network size, N, is the number of contacts in a person's network. In graph-theory discussions, the size of the network around a person is discussed as "degree." For non-zero network size, other things equal, more contacts mean that a manager is more likely to receive diverse bits of information from contacts and is more able to play their individual demands against one another. Network constraint is lower in larger networks because the proportion of a manager's network time and energy allocated to any one contact (p_{ij} in the constraint equation) decreases on average as the number of contacts increases.

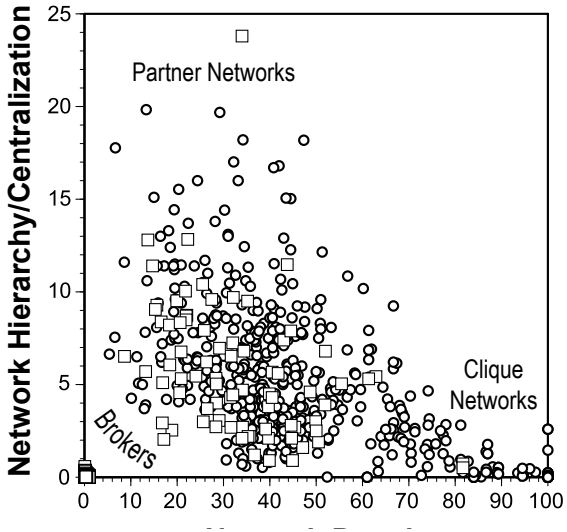
Density

Density is the average strength of connection between contacts: $\Sigma z_{ij} / N*(N-1)$, where summation is across all contacts i and j. Dense networks are more constraining since contacts are more connected ($\Sigma_q p_{iq} p_{qj}$ in the constraint equation). Contact connections increase the probability that the contacts know the same information and eliminate opportunities to broker information between contacts. Thus, dense networks offer less of the information and control advantage associated with spanning structural holes. Density is only one form of network closure, but it is a form often discussed as closure.

Hypothetical networks in the table on the next page illustrate how constraint varies with size, density, and hierarchy. Relations are simplified to binary and symmetric in the networks. The graphs display relations between contacts. Relations with the person at the center of the network are not presented (that person at the center is referenced by various labels such as "you," "ego," or "respondent"). The first column in the table contains examples of sparse networks (zero density). No contact is connected with other contacts. The third column in the table contains maximum-density networks (density = 100). Every contact has a strong connection with each other contact. At each network size, constraint is lower in the sparse-network column.

Broker Networks, Partner Networks, and Clique Networks

	Broker Networks	Partner Networks	Clique Networks
Small Networks			
contacts	3	3	3
density x 100	0	67	100
hierarchy x 100	0	7	0
constraint x 100	33	84	93
from:			
A	11	44	31
B	11	20	31
C	11	20	31
nonredundant contacts	3.0	1.7	1.0
betweenness (holes)	3.0	0.5	0.0
Larger Networks			
contacts	5	5	5
density x 100	0	40	100
hierarchy x 100	0	25	0
constraint x 100	20	59	65
from:			
A	4	36	13
B	4	6	13
C	4	6	13
D	4	6	13
E	4	6	13
nonredundant contacts	5.0	3.4	1.0
betweenness (holes)	10.0	3.0	0.0
Still Larger Networks			
contacts	10	10	10
density x 100	0	20	100
hierarchy x 100	0	50	0
constraint x 100	10	41	36
nonredundant contacts	10.0	8.2	1.0
betweenness (holes)	45.0	18.0	0.0



Network Constraint

decreases with number of contacts (size), increases with strength of connections between contacts (density), and increases with sharing the network (hierarchy/centralization).

This is Figure 1 in Burt, "Reinforced Structural Holes," (2015, *Social Networks*, an elaboration of Figure B.2 in *Neighbor Networks*). Graph above plots density and hierarchy for 1,989 networks observed in six management populations (aggregated in Figure 2.4 in *Neighbor Networks* to illustrate returns to brokerage). Squares are executives (MD or more in finance, VP or more otherwise). Circles are lower ranks. Executives have significantly larger, less dense, and less hierarchical networks.

To keep the diagrams simple, relations with ego are not presented.

Hierarchy/Centralization

Density is a form of closure in which contacts are equally connected. Hierarchy is another form of closure in which a minority of contacts, typically one or two, stand above the others for being more the source of closure. The extreme is to have a network organized around one contact. For people in job transition, such as M.B.A. students, that one contact is often the spouse. In organizations, hierarchical networks are sometimes built around the boss.

Hierarchy and density both increase constraint, but in different ways. They enlarge the indirect connection component in network constraint ($\Sigma_q p_{iq} p_{qj}$). Where network constraint measures the extent to which contacts are redundant, network hierarchy measures the extent to which the redundancy can be traced to a single contact in the network. The central contact in a hierarchical network gets the same information available to the manager and cannot be avoided in manager negotiations with each other contact. More, the central contact can be played against the manager by third parties because information available from the manager is equally available from the central contact since manager and central contact reach the same people. Network constraint increases with both density and hierarchy, but density and hierarchy are empirically distinct measures and fundamentally distinct with respect to network advanage because it is hierarchy that measures advantage borrowed from a sponsor (this point is the focus of the later session on outsiders having to borrow network access from a strategic partner).

To measure the extent to which the constraint on a person is concentrated in certain contacts, I use the Coleman-Theil inequality index for its attractive qualities as a robust measure of hierarchy (Burt, 1992:70ff.). Applied to contact-specific constraint scores, the index is the ratio of $\Sigma_j r_j \ln(r_j)$ divided by N ln(N), where N is number of contacts, r_j is the ratio of contact-j constraint over average constraint, $c_{ij}/(C/N)$. The ratio equals zero if all contact-specific constraints equal the average, and approaches 1.0 to the extent that all constraint is from one contact. Again, I multiply scores by 100 and report integer values.

In the first and third columns of the table on the previous page, no one contact is more connected than others, so all of the hierarchy scores are zero. Non-zero hierarchy scores occur in the middle column, where one central contact is connected to all others who are otherwise disconnected from one another. Contact A poses more severe constraint than the others because network ties are concentrated in A. The Coleman-Theil index increases with the number of people connected to the central contact. Hierarchy is 7 for the three-contact hierarchical network, 25 for the five-contact network, and 50 for the ten-contact network. This feature of hierarchy increasing with the number of people in the hierarchy turns out to be important for measuring the network advantage of outsiders because it measures the volume of opportunity borrowed from a sponsor, which strengthens the association with performance.

Note that constraint increases with hierarchy and density such that evidence of density correlated with performance can be evidence of a hierarchy effect. Constraint is high in the dense and hierarchical three-contact networks (93 and 84 points respectively). Constraint is 65 in the dense five-contact network, and 59 in the hierarchical network; even though density is only 40 in the hierarchical network. In the ten-contact networks, constraint is lower in the dense network than the hierarchical network (36 versus 41), and density is only 20 in the hierarchical network. Density and hierarchy are correlated, but distinct, components in network constraint.

Appendix III:

Quick Metric Regression Coefficients for log Network Constraint