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Bridge Decay

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University of Chicago, Institute Européen d'Administration d'Affaires (INSEAD),
and Raytheon Company
Address: Graduate School of Business, University of Chicago, Chicago, IL 60637;
773-702-0848; ron.burt@gsb.uchicago.edu; http://gsb.uchicago.edu/fac/ronald.burt)

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ABSTRACT

This paper is about three points: network bridges are critical to the advantage known as social capital, bridges relative to other kinds of relationships show faster rates of decay over time, and the faster decay in bridges has implications for the stability of social capital. A bridge connects people not otherwise connected; in other words, it spans a structural hole in the surrounding organization. I have four years of data on the social networks of bankers in a large organization. I show that bridge relations are associated with more positive peer reputations and higher compensation, but decay at an alarming rate. Nine in ten bridges this year are gone next year. I describe factors in the rate of decay, find slower decay in the networks of bankers experienced with bridge relationships, and conclude that social capital accrues to those who already have it. An appendix is included on the kinked decay functions observed in contractual bridge relationships.

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For four years, bankers in a large financial organization were each asked to name and evaluate colleagues with whom the banker had frequent and substantial business during the previous year. I use these data to describe network decay in association with banker performance. Relationships are most often within groups, but some are bridges between groups. The bridges were social capital in that bridge relations are associated with more positive peer evaluations and higher bonus compensation. The demonstrative value of bridge relationships makes it all the more striking to see them decay so quickly. Nine in ten bridge relations this year are gone next year. Surviving relationships are less subject to decay, especially bridges. Bridge relationships decay more quickly than nonbridges in their first two years. By the fourth year, both are down to the same number of survivors: one in a hundred. Thereafter, bridges decay more slowly than nonbridge relations. So, the key to bridge survival is to make it past the high death rate in new bridges, which seems to depend on experience. Bridge decay is less likely in the networks of bankers who have more experience with bridges. This is consistent with laboratory results on people learning networks: People on average find it difficult to see the structural holes in a network, and those whose own networks contain bridge relationships more quickly learn new networks that contain structural holes. In as much as bridges are social capital, and bridges are less subject to decay for people more experienced with bridges, I conclude that social capital accrues to those who already have it.

The Social Capital of Bridges

This section, abbreviated from a detailed review of argument and evidence (Burt, 2000b), is a quick introduction to the social capital of bridge relationships.

Social Capital

The social capital metaphor is that certain people have an advantage because they are better connected to other people. Think of society as a market in which individuals and groups exchange ideas, goods, support, et cetera. Over time, certain people meet more frequently. Certain people have sought one another out. Certain people have completed exchanges with one another. There is at any moment a network, as illustrated in Figure 1, in which individuals are variably connected to one another as a function of prior contact, exchange, and attendant emotions. Figure 1 is a generic sociogram and density table description of a network. People are dots. Relationships are lines. Solid (dashed) lines connect pairs of people who have a strong (weak) relationship. Cell (A,B) of the density table is the average strength of relationship between people in groups A and B.

In theory, the network residue from yesterday should be irrelevant to market behavior tomorrow. I buy from the seller with the most attractive offer. That seller may or may not be the seller I often see at the market, or the seller from whom I bought yesterday. So viewed, the network in Figure 1 would recur tomorrow only if buyers and sellers come together as they have in the past. Recurrence would have nothing to do with the prior network as a casual factor. It would be only a by-product of buyers and sellers seeking one another out as a function of supply and demand.

Selecting the best exchange, however, requires that each person has information on available goods, sellers, buyers, and prices. Information can be expected to spread across the people in a market, but it will circulate within groups before it circulates between groups. A generic research finding is that information circulates more within than between groups — within a work group more than between groups, within a division more than between divisions, within an industry more than between industries (e.g., Festinger, Schachter and Back 1950, is often cited as an early exemplar in this research). For example, the sociogram in Figure 2 shows three groups (A,B,C), and the density table at the bottom of the figure shows the generic pattern of in-group relations stronger than relations between groups in that diagonal elements of the table are higher than off-diagonals (each cell of a density table is the average of relations between individuals in the row and individuals in the column). The result is that people are not simultaneously aware of opportunities in all groups. Even if information is of high quality, and eventually reaches everyone, the fact that diffusion occurs over an interval of time means that individuals informed early or more broadly have an advantage.

Bridges across Structural Holes

Participation in, and control of, information diffusion underlies the social capital of structural holes (Burt, 1992, 2000b, 2002). The argument describes social capital as a function of brokerage opportunities, and draws on network concepts that emerged in sociology during the 1970s; most notably Granovetter (1973) on the strength of weak ties, Freeman (1977, 1979) on betweenness centrality, Cook and Emerson (1978) on the benefits of having exclusive exchange partners, and Burt (1980) on the autonomy created by complex networks. More generally, sociological ideas elaborated by Simmel (1955 [1922]) and Merton (1968 [1957]) on the autonomy generated by conflicting affiliations are mixed in the hole argument with traditional economic ideas of monopoly power and oligopoly to produce network models of competitive advantage.

——— Figure 1 About Here ———

The weaker connections between groups in Figure 1 are holes in the social structure of the market. These holes in social structure — or more simply, structural holes — create a competitive advantage for an individual whose relationships span the holes. The structural hole between two groups does not mean that people in the groups are unaware of one another. It only means that the people are focused on their own activities such that they do not attend to the activities of people in the other group. Holes are buffers, like an insulator in an electric circuit. People on either side of a structural hole circulate in different flows of information. Structural holes are thus an opportunity to broker the flow of information between people, and control the projects that bring together people from opposite sides of the hole.

Structural holes separate nonredundant sources of information. Nonredundant contacts offer information that is more additive than overlapping. There are two network indicators of redundancy: cohesion and equivalence. Cohesive contacts, contacts strongly connected to each other, are likely to have similar information and therefore provide redundant information benefits. Structurally equivalent contacts, contacts who link a manager to the same third parties, have the same sources of information and therefore provide redundant information benefits.

Robert and James in Figure 1 have the same volume of connections, six strong ties and one weak tie, but Robert has something more. James is connected to people within group B, and through them to friends of friends all within group B. James can be expected to be well informed about cluster B activities. Robert is also tied through friends of friends to everyone within group B, but in addition, his strong relationship with contact 7 is a conduit for information on group A, and his strong relationship with 6 is a conduit for information on group C. His relationship with 7 is for Robert a network bridge in that the relationship is his only direct connection with group A. His relationship with contact 6 meets the graph-theoretic definition of a network bridge. Break that relationship and there is no connection between groups B and C. More generally, Robert is a broker in the network. Network constraint is an index that measures the extent to which a person‘s contacts are redundant (Burt, 1992, 2000b). James has a constraint score twice Robert’s (30.9 versus 14.8) and Robert is the least constrained person in Figure 1. Network betweenness, proposed by Freeman (1977, 1979), is an index that measures the extent to which a person brokers indirect connections between all other people in a network. Robert’s betweenness score of 47.0 shows that almost half of indirect connections run through him. His score is the highest in Figure 1, well-above the average 6.5 score, and much higher than James’ below-average 5.2 score.

Competitive Advantage

Robert’s bridge relationships enhance his access to information. The volume of information to which he is connected is higher because he reaches more people indirectly. Further, the diversity of his contacts across the three separate groups means that his higher volume of information contains fewer redundant bits of information. Further still, Robert is positioned at the cross-roads of social organization so he is early to learn about activities in the three groups. He corresponds to the opinion leaders proposed in the early diffusion literature as the individuals responsible for the spread of new ideas and behaviors (Burt, 1999b). Also, Robert’s more diverse contacts mean that he is more likely to be a candidate discussed for inclusion in new opportunities. And there is a feedback loop in which benefits beget more benefits: Robert's early access to diverse information him more attractive to other people as a contact in their own networks.

There is also a control advantage. Robert's information benefits make him more likely to know when it would be valuable to bring together certain disconnected contacts, which gives him disproportionate say in whose interests are served when the contacts come together. More, the holes between his contacts mean that he can broker communication while displaying different beliefs and identities to each contact. Robert in Figure 1 is an entrepreneur in the literal sense of the word — a person who adds value by brokering connections between others (Burt, 1992, 30-36; Burt, 2000b, on the connection with contemporary research on entrepreneurship). In terms of the argument, networks rich in the entrepreneurial opportunities of structural holes are entrepreneurial networks, and network entrepreneurs are people skilled in building the interpersonal bridges that span structural holes. There is tension here, but not the hostility of combatants so much as the uncertainty of change. In the swirling mix of preferences characteristic of social networks, value is created by network entrepreneurs strategically moving accurate, ambiguous, or distorted information between people on opposite sides of structural holes in the routine flow of information. The information and control benefits of bridging the holes reinforce one another at any moment in time, and cumulate together over time.

In sum, individuals with networks rich in structural holes are the individuals who know about, have a hand in, and exercise control over, more rewarding opportunities. The behaviors by which they develop the opportunities are many and varied, but opportunity itself is defined by a hole in social structure. Network entrepreneurs monitor information more effectively than bureaucratic control. They move information faster, and to more people, than memos. They are more responsive than a bureaucracy, easily shifting network time and energy from one solution to another. More in control of their surroundings, brokers like Robert in Figure 1 can tailor solutions to the specific individuals being coordinated, replacing the boiler-plate solutions of formal bureaucracy. To these benefits of faster, better solutions, add cost reductions; entrepreneurial managers offer inexpensive coordination relative to the bureaucratic alternative. Speeding the process toward equilibrium, individuals with networks rich in structural holes operate somewhere between the force of corporate authority and the dexterity of markets, building bridges between disconnected parts of a market where it is valuable to do so.

The prediction is that in comparisons between otherwise similar people like James and Robert in Figure 1, it is Robert who has more social capital. His network of bridge relationships across structural holes gives him broad, early access to, and entrepreneurial control over, information. Consistent with the prediction, there is an accumulating body of research in which networks that span structural holes are associated with creativity and learning, adaptive implementation, more positive evaluations, more successful teams, early promotion, and higher compensation (for review, see Burt, 2000b, 2002).

Bridges and Social Capital in Investment Banking

The study population for this paper comes from the investment banking division of a large financial organization. The employees to be analyzed, I will discuss them as bankers, include senior people responsible for making and closing deals, as well as people in administrative positions who manage bankers in lower ranks, or manage analysts who service the bankers.

Colleague Networks

The work of this population requires flexible cooperation between colleagues. It is impossible to monitor their cooperation through bureaucratic chains of command because much of their interpersonal behavior is unknown to their immediate supervisor. The firm is typical of the industry in using peer evaluations to monitor employee cooperation. Each year, officers are asked to identify the people with whom they had substantial or frequent business dealings during the year and to indicate how productive it was to work with each person (poor, adequate, good, or outstanding; these are my synonyms for the words actually used). The ratings guide promotion and bonus decisions, so virtually all eligible employees respond.

As is typical of companies using peer evaluations, the banker evaluations are only used to compute average evaluations. However, there is network structure in the evaluations, and that network structure has social-capital implications for an officer's performance, which in turn should affect bonus compensation (see Eccles and Crane, 1988, Chap. 8). From peer evaluations by the investment officers and colleagues in other divisions of the firm, I identified the people cited as productive contacts by each of the officers, then looked at the evaluations by each contact to see how contacts evaluated one another.

I have four years, or panels, of network data on 345 bankers in the study population (there are many thousands more relations with and among non-bankers in the organization). If a banker cited a colleague in each panel, the relationship appears in the data four times. A banker's network in a panel is the set of colleagues he or she cited that year as frequent and substantial business contacts. In the familiar dichotomy between strong and weak ties, note that these "frequent and substantial business" relationships are strong ties. I have no data on the potential social capital of weak-tie bridges, but among the strong ties on which I do have data, the strongest are less subject to decay, so the decay I find in strong-tie bridges is probably even more striking in weak-tie bridges.

Each banker-colleague relationship is embedded in some number of indirect connections through other employees as third parties. I will discuss such connections as third-party ties. I measure third-party ties by multiplying relationships through shared contacts: a third-party tie from banker to colleague through a specific contact is the banker's evaluation of the contact multiplied by the contact's evaluation of the colleague. In Figure 1, for example, James' relationship with contact 3 is embedded in two third-party ties. All of Robert's relationships are bridges. None are embedded in any third-party ties.

<u>For the purposes here, I treat a banker-colleague relationship as a bridge if there are no positive third-party ties from banker to colleague.</u> My understanding from discussions with company executives is that good or outstanding evaluations are positive. Evaluations of adequate or poor are negative. A third-party tie is positive if the multiplied evaluations are both positive or both negative (analysis of

these data elsewhere shows that either form of a positive third-party tie slows decay, Burt, 2000a:Table 5). A third-party tie is negative if the evaluations are contradictory, e.g., a contact about whom the banker has a negative opinion makes a positive evaluation of the colleague. The vast majority of the banker-colleague relations at risk of decay, 92%, are embedded in one or more positive third-party ties. The remaining 8% are bridges — either in the graph-theoretic sense of there being no third parties to the relationship, or because there are only contradictory relations with third parties. The two forms of bridges are equally likely in this study population and decay at about the same rate (see Figure 2 below).

Consistent with descriptions of investment banking in the business press (e.g., Eccles and Crane, 1988; Lewis, 1989), the image I infer from the network data is a social system loosely integrated at the macro level but tightly integrated at the micro level. Most of a banker's colleagues do not cite one another. Citation density varies across time and bankers from zero up to 84.4%, around an average of 27.3%. The 27.3% average means that one in four pairs of colleagues are connected by a citation. The organization is too large for every person to have frequent and substantial business contact every year with every other person. More importantly, redundant communication channels and peer pressure enforcing social norms do not require global density if there are overlapping spheres of local density. Although most of a banker's colleagues do not cite one another, almost every relationship with a colleague is embedded in third-party ties. In fact, the average banker-colleague relationship is embedded in eight third-party ties, five of them positive. Density is low within the banker networks, but almost every banker relationship with a colleague exists in a social setting of third parties.

Social Capital

The results in Table 1 show how bridges are associated with performance, and so constitute social capital for the bankers. Data are pooled across panels to focus on relative social capital and performance over time. The results are not about causal direction, only association with certain factors held constant.[1]

——— Table 1 About Here ———

Model I shows that bankers with more bridges in their network received more positive peer evaluations. Evaluations are scored 1, 2, 3, 4 for poor, adequate, good, and outstanding. A banker's peer-evaluation score in Table 1 is the average across all evaluations he or she received at any time in the four years under study. Job rank is a banker's average rank across the four years (raw scores are 1 to 5, squared are 1 to 25). Model I shows that evaluations are more positive for bankers in more senior ranks, increasing more than linearly across ranks. The final predictor in Model I is a measure of social capital: the number of bridges in a banker's network (where, as explained above, a banker-colleague relation is a bridge if there are no positive indirect connections from banker to colleague through third parties). The average within-panel number of bridges is 3.2 per banker. Summing across all panels, the average banker was involved in eight bridge relations. Model I shows that bankers with more bridge relations received more positive peer evaluations (3.5 t-test).

Models II and III predict banker compensation. Compensation, taken from the organization's archives, includes salary, cash bonus, and cash value of stock. To preserve confidentiality, compensation is measured here as a percentage of the maximum (100 times banker's compensation divided by the highest compensation any banker received that year). The maximum went to a different banker in each of the four panels. The compensation measure in Table 1 is the natural logarithm of the average score for a banker across panels (I get the same pattern of effects with the log of a banker's best year).

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[1]Two processes occur within the averages. Scores on average increase with time. Tenure increases by definition one year for each panel. Neither rank nor compensation increase with the consistency of tenure — since the bankers sometimes move to a lucrative job at lower rank, and the bulk of a banker's compensation is bonus, which can vary from one year to the next — but both variables on average increase over time (t-tests of 4.4 for job rank and 10.7 for compensation). A second process, selection, also increases mean scores on the variables over time by culling from the study population bankers with low scores. Almost half of the bankers leave by the end of the fourth panel, and the Model IV and V results in Table 1 show that exit is not random. Bankers who stay receive positive peer evaluations (which therefore increase on average over time, 5.1 t-test) and high compensation (10.7 t-test for the increase over time). To establish with Table 1 the social capital of bridges, I am concerned with aggregate associations among relative levels of these variables over time. Decay will be analyzed from year to year.

Compensation increases exponentially with job rank and decreases linearly with tenure. The average banker had been with the organization for 8.17 years. More or fewer years have no association with peer evaluations, but compensation is higher for bankers with more years in the organization (4.2 t-test, P < .001). The tenure association is due to job rank, not time. Bankers with the organization for many years tend to have been promoted to senior rank. Holding job rank constant, Model II shows that the direct association between compensation and tenure is negative.

The model also shows higher compensation going to bankers in more bridge relationships. The association with bridges is reduced slightly when peer evaluations are held constant, but remains statistically significant (3.8 t-test, P < .001, in Model III). The same conclusion holds with more sophisticated measures of social capital (Burt, 1997:350; 2000b:376).

Models IV and V predict banker exit. I include exit to show that bridges have no direct association with bankers leaving the study population. Of bankers in the first panel, about half stay with the organization across all four panels (345 bankers in panel one drops to 191 in panel four). The exit variable in Table 1 distinguishes those who left from those who stayed across all four panels. Bankers who have the social capital of bridge relationships are less likely to leave (-4.1 t-test in Model IV), however, the association is negligible when peer evaluations and compensation are held constant (Model V). The association is slightly stronger in an order logit model that distinguishes exit in an early panel from exit in a later panel (rather than the aggregate exit variable in Table 1), but remains negligible when peer evaluations and compensation are held constant.

In sum, and in keeping with other research on social capital, bridge relations are associated with more positive job evaluations and higher compensation, both of which decrease the probability of a banker leaving the organization.

Decay In Theory

Despite the known performance-implications of bridges, we know almost nothing about their origins and decay. In fact, putting aside research on small groups (in which continuous visibility gives relationships properties distinct from relationships in large groups), and putting aside research on contractual bridges such as marriage, employment, and interorganizational relations (discussed in the Appendix), there is almost no research on the stability of interpersonal relationships, let alone bridge relations in particular (see Burt, 2000a:Table 1, for review). I begin with baseline decay processes, then turn to bridge decay in particular.

Liability of Newness

Other things equal, relationships weaken over time such that some observed today are gone tomorrow. The tendency for relations to weaken and disappear I will discuss as decay, functions describing the rate of decay over time I will discuss as decay functions, and variables in the functions I will discuss as decay factors (Burt, 2000a).

More specifically, there is reason to expect a liability of newness like the phenomenon described by population ecology models of organizations (Hannan and Freeman, 1989:80) in which relations decay over time, but more slowly in surviving relations. The decay process would begin with people becoming acquainted as a function of random chance and exogenous factors. People who would not otherwise seek one another out can find themselves neighbors, colleagues in the same company, assigned to the same project team, or seated next to one another. It is rude not to strike up a relationship (e.g., Blau, 1977; 1994, on the opportunities and constraints that social structures create for relations to emerge, Feld, 1981, on the social foci from which relations emerge; Festinger, Schachter, and Back, 1950, for the classic study in this genre). The relationships can be bridges to other groups when they result from events that bring people together from separate groups, events such as cross-functional teams, inter-department committees, or inter-organizational conventions and professional meetings. People in these relationships often discover that they do not enjoy one another, or cannot work well together, so they disengage in favor of more compatible contacts. The selection process in which new (hoped to be) compatible contacts replace existing (known to be) incompatible ones means that relations on average weaken and decay over time (barring the process-obscuring endowments discussed in the Appendix). A liability of newness occurs because the longer a relationship has survived, the more likely that it connects people who have learned to appreciate one another, which increases the probability of the relationship continuing into the future.

Learning is more than an accompanist to selection processes. There is also learning from your current relationships to identify kinds of people with whom you are likely to be compatible. Whatever the average probability of a new relationship disappearing next year, that probability should be lower for people more experienced in the study population because experienced people have learned to identify partners with whom they can be compatible.

In sum, there are two kinds of aging responsible for a liability of newness. One is the age of a relationship, call it tie age, for which the liability of newness is evident from slower decay in older relationships. Second is the age of the person citing a relationship, call it node age, for which the liability of newness is evident from slower decay in relations cited by people with more experience in the study population.

Implications for Bridge Decay

The social capital benefits of bridges are an incentive to build them, but maintaining them is another matter. Consider Robert's relationship with contact 6, which gives him access to group C in Figure 1. If not contact 6, then some other contact in the group could provide access. The benefit for Robert of continuing with contact 6 is that a history of interaction can decrease the cost of a relationship while increasing trust and reliability within the relationship (e.g., see Burt, 1999a, 2001a, for literature review). On the other hand, there is no evidence that social capital is limited to bridges that continue over time. People involved in bridge relations could derive their advantage simply from being more exposed to contradictory information — which can happen with short-term or long-term bridges — from which people become adept at synthesizing and communicating ideas across contradictory views (see Burt, 2002, on creativity, learning, and adaptive implementation).

A further complication is that bridges are in two ways more costly to maintain. First, the cost is shared by fewer people. The cost of maintaining a bridge is borne entirely by the two parties to the bridge, e.g., Robert and contact 6 in Figure 1. In contrast, the relationship between James and contact 4 is in some part maintained by their three mutual friends. Second, the cost of the relationship is higher. Research on the tendency for people to have relations with people like themselves implies that bridges require more effort to maintain. For reasons of opportunity and interpersonal attraction, relations are observed more often between people similar on socially significant attributes such as spatial proximity, socioeconomic status, gender, and age (e.g., Festinger, Schachter and Back, 1950; Lazarsfeld and Merton, 1954; Blau, 1977, 1994; Feld, 1981; Pfeffer, 1983; McPherson, Popielarz, and Drobnic, 1992; Reagans and Burt, 1998). For reasons of information flow and enforceable social norms, relationships embedded in dense networks are more likely to be strong (e.g., Granovetter, 1985 on structural embedding and trust; Coleman, 1990 on social capital and trust; Burt ,1999a, 2001a on gossip and trust). To the extent that embedding facilitates the development of strong relations, it could be expected to slow their decay (making them "sticky," Krackhardt, 1998).

Given ambiguous advantages to maintaining bridges, and unambiguously higher cost, bridges should be more subject to the liability of newness, and so should decay more quickly than other kinds of relationships.

Decay Observed

Decay in the banker networks is striking. Let the decay rate be the probability that a relationship observed this year will be gone next year. In the first row of Table 2, for example, 801 bridge relationships were cited in the first panel (P = 1). In the second panel, after one year, only one in ten are re-cited (T = 1; 720 of 801 bridges decay, .90 decay rate).[2]

The liability of newness is evident from lower decay rates in older relationships. Of the 81 bridges that survive into the second panel, 66 decay before the third panel,

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[2]Table 1 does not contain all of the banker relations. For the 22,709 relations in Table 1, I know its strength at time T, third-party ties in which the relationship was embedded at time T, and whether the relationship is cited again in year T+1. There are another 2,229 relationships first cited in the last panel. I do not know which of these decays in the following year, so they are excluded from the event-history analysis.

which is a .81 decay rate. Of the 15 bridges that survive into the third panel, 6 decay before the fourth panel, which is a .40 decay rate. The next row of Table 2 displays 670 new bridges cited in the second panel. After one year, only 62 were cited again, which repeats the one-year decay rate observed in the first panel (608 of 680 bridges decay, .91 decay rate).

——— Table 2 and Figure 2 About Here ———

Compare the decay rates for bridges and nonbridges in Table 2. With one exception (based on a small number of observations), decay rates are higher for the bridge relationships.[3] This is consistent with related studies. Feld (1997) analyzes network data on 152 students enrolled in a small college at the beginning and end of their freshman year. Of 5,345 initial sociometric citations for recognition, 54% were observed again in the second survey, but the percentage increases significantly with mutual acquaintances. Krackhardt (1998) analyzes network data gathered over a semester on 17 sophomore college students living together. He too finds that a relationship is more likely to continue when the two students have mutual friends. Burt (2000a) describes decay in the banker networks analyzed here. Decay is less likely when banker and colleague have mutual contacts, and the slower decay in relations between socially similar (homophilous) bankers can be attributed to such bankers having more mutual contacts with other colleagues.

Ceteris Paribus

The conclusion that bridges decay faster is given more solid foundation by the logit results in Figure 2. The first predictors are controls for marginals and local structure.

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[3]Decay is so much higher for bridges that I describe them separate from nonbridge relations to simplify the presentation of evidence. Visibility notwithstanding, it is reassuring to know that the differences between bridges and nonbridges are statistically significant. Here is a quick illustration with the results in Figure 2: Decay is in part a function of time (decay less likely in older relations), and panel (decay less likely for more experienced bankers). The two predictors can define a logit model of decay; f = a + bT + cP, where the lower-case letters are parameters to be estimated, and T and P are the predictors. Parameter estimates for bridge relations separate from nonbridges show significantly negative effects for the predictors (coefficients b and c; as reported in Figure 2), and a higher intercept for bridges showing that bridges are more subject to decay (first row of table in Figure 2). A model of the pooled data provides a statistical test of the difference between bridge and nonbridge relations: f = $\underline{a}$ + $\underline{b}$T + $\underline{c}$P + dBRIDGE + e(T x BRIDGE) + f(P x BRIDGE), where BRIDGE is a dummy variable equal to 1 for the 1,809 relationships in Figure 2 that are bridges. Estimates for the added coefficients are significant at well beyond a .001 level of confidence. The 7.1 test statistic for coefficient d shows that decay is higher in bridges, -4.4 for coefficient e means that decay slows more quickly in bridges, and -3.0 for coefficient f shows that decay is less for more experienced bankers.

If a banker cites many colleagues (row marginal of the banker network) and a colleague is often cited (column marginal of the company network), then the probability of a banker-colleague citation is higher by random chance than between a banker who made few citations and a colleague rarely cited. The first predictor in Figure 2 shows that decay is less likely between more socially active bankers and colleagues.[4]

Network structure immediately adjacent to a relationship includes prior contact, homophily, and third parties ("local structure" variables in Figure 2). Prior contact between banker and colleague could have been in some degree positive (2 for outstanding, 1 for good, 0 for less than good) or negative (2 for poor, 1 for adequate, 0 for better than adequate). Bridge decay is independent of the prior relationship, which implies that bridges must be maintained for reasons other than banker satisfaction with the colleague. Satisfaction is a factor in the decay of nonbridges. Relationships evaluated more positive last year are less subject to decay (-4.8 test statistic) although negative relationships are not systematically discontinued (0.4 test statistic). In a social system such as this, where relations decay so quickly, bankers do not have to decide to discontinue a relationship. It will quickly die of natural causes unless an effort is made to sustain it.

People in investment banking are their own breed, so it is not surprising to see that banker relations with colleagues in other divisions are more subject to decay. Most relations are not bridges, so the effect in Figure 2 is a significant test statistic in the decay function for nonbridge relations (7.3 test statistic). I presume, but cannot determine, that this results from cross-functional project teams. Connection with the colleague ends when the project ends — despite the fact that banker and colleague were connected indirectly through other team members as third parties. All the more interesting to see that bridge decay is independent of corporate boundaries in Figure

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[4]There are two parts to the control for marginals: the higher probability of a citation between socially active employees, and the impossibility of a citation if either banker or colleague has left the company. I cannot add a control variable for exit because there is no decay variance in relations between bankers or colleagues who have left — all relations with them have decayed. However, the strong negative association between decay and network marginals measures more than employee exit. If I re-estimate the models in Figure 2 using only data on bankers and colleagues who continue to work for the company through year T, the test statistics are not much reduced (-5.1 and -6.7 drop slightly to -4.9 and -6.6 respectively).

2 (0.7 test statistic). Bridge relations to other divisions of the organization are no more subject to decay than bridge relationships within the division.

LIABILITY OF NEWNESS

The liability of newness is evident for bridge and nonbridge relations. With respect to node age, relations first cited by the continuing bankers in later panels are less subject to decay (-4.7 and -5.8 test statistics for bridges and nonbridges, $P < .001$). With respect to tie age, relationships that last longer are less subject to decay (-6.9 and -6.2 test statistics for bridges and nonbridges, $P < .001$). The graph in Figure 2 provides a visual display (with all predictors but time fixed at their mean values for the category of relationships in which decay is predicted). The vertical axis is the probability that a continuing relationship is not cited next year. The horizontal axis is tie age: 0 is the year in which a relation is initially observed, 1 is a year later, 2 the year after that, and so on. The downward sloping lines describe how the probability of decay decreases across the years for which a banker and colleague have worked with one another.

At the same time, the graph illustrates the greater degree to which bridges are affected by the liability of newness. The dashed line describes bridge decay. Decay is likely when a bridge is first created (.97 probability when T equals 0), but the risk of decay drops quickly if the bridge survives for a few years.

The bold line in Figure 2 describes decay in nonbridge relationships. The risk of decay decreases slowly with tie age, from a .83 probability in a relationship just begun, down to a .20 probability in a relationship that survives for eight years. The gray area around the bold line illustrates how decay varies with the number of positive third-party ties in which banker and colleague are embedded. The logit models show no effect from the number of negative third-party ties (which is why it seemed reasonable to combine them with pure bridges — no third-party ties — to increase the number of bridges available for analysis). There is also no effect of positive third-party ties on bridge decay because there are by definition no positive third-party ties embedding bridges. Decay in nonbridges, however, slows with the number of positive third-party ties. The gray area around the bold line in the graph is bounded at the top by predicted decay for a nonbridge relationship embedded in one positive third-party tie, and bounded at the bottom by the prediction for eight (75% of nonbridges are embedded in less than eight positive third-party ties). The point illustrated is that the decay difference between bridges and nonbridges is robust to the number of third-party ties in which a nonbridge relationship is embedded.

——— Table 3 About Here ———

Decay rates are an abstraction. To make the results more concrete, the first two columns of Table 3 contain the number out of 100 relations predicted to survive over time by the decay functions in Figure 2. Bridges decay more quickly than nonbridge relations in the first two years. By the fourth year, however, both kinds of relationships are down to the same number of survivors: one in a hundred. Thereafter, bridge relations decay more slowly than nonbridges. In other words, bridge relations are more likely to survive than relations embedded in third-party connections — if they can survive the first years. The trick is to make it past the high death rate in new bridge relationships.

The other three columns in Table 3 are a frame of reference. Relationship survival within and beyond the family is averaged across several studies (see Burt, 2000a: Figure 1A, for the survival functions and discussion). Surviving numbers of the banker-colleague relations are slightly higher than predicted by the Figure 2 graph because the control variables assigned mean values for the graph in fact co-vary with tie age. The liability of newness is still obvious. Decay is rapid in the initial years of a relationship. And the liability of newness is not peculiar to the bankers. The final two columns in Table 3 describe social relations with relatives, and with friends and acquaintances beyond the family. Decay in a family relationship does not mean that a former relative is now excluded from the family (though it does include death of the relative). Decay here refers to the continued active use of relationships. Decay in a family relationship typically means that a relative who was cited as a confidant (for example) last year, is not cited this year. The point illustrated in Table 3 is that decay in relations with family and friends is concentrated in the initial years of a relationship, as it is for the bankers in their relations with colleagues. The difference is that decay is slower. Where 1% to 5% of banker relations with colleagues survive to age four, 32% of relations with friends and acquaintances survive that long, and about half of family relationships survive that long.

Implications for Social Capital

Faster decay in bridge relations could have profound implications for the stability of social capital because more valuable relationships are more prone to decay. For the individual, this means that disproportionate attention has to be given to maintaining current bridge relations (disproportionate because nonbridge relations are in part preserved by the third parties to the relationship), or disproportionate attention has to be given to acquiring new contacts in other groups to replace old bridge connections, or strategies have to be devised to quickly recognize and act on the value of bridge relationships before they fade away. For the organization, the faster decay means hiring employees who have, and are able to maintain/replace/recognize social capital. Or, if individuals cannot manage the faster decay in bridges, the decay would be concentrated in the networks around people who have social capital (because that is where bridges are more likely to occur), eroding their social-capital advantage over time. If this were true, then maintaining a volume of network bridges in an organization would require hiring new people whose initial relations within the organization are by definition bridges, until the new people also settle in and have to be replaced with new entrants.

Decay and Banker Performance

Figure 3 illustrates network changes possible with respect to bridges, and lists the relative frequency with which each kind of change occurred in the banker networks. The options are continuity, transformation, decay, or birth.[5] Bridges and nonbridges

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[5]The counts in Figure 3 come from the following cross-tabulation of relations in adjacent years, where columns indicate a relation's condition this year (bridge, nonbridge, or not cited), and rows indicate its condition last year:

127	121	1,561
756	5,030	15,114
1,403	6,206	empty

can continue or decay from one year to the next (respectively in Figure 3, relations A and B, or E and F). What was a bridge can become a nonbridge if relationships develop with mutual acquaintances (illustrated in Figure 3 by relation C). A relationship that was embedded in a third-party tie can become a bridge if the banker loses contact with the third party (relation D in Figure 3).

——— Figure 3 About Here ———

The results in Figure 3 show decay concentrated around low-performance bankers. The performance distinction separates bankers who, relative to peers, are better paid and more highly praised by colleagues.[6] High-performance bankers are fewer in number, but they have larger networks so a disproportionate number of the changes occur in their networks (an average of 109, versus 66 for a low-performance banker). Holding that marginal difference constant, along with banker rank and years with the organization, the logit test statistics in Figure 3 are for a model predicting the performance dichotomy from the frequencies with which each kind of change occurs in a banker's network (relative to continuing nonbridge relations as a reference category).[7] The statistically significant differences are that high-performance bankers experience less decay in their bridge relations (-3.0 test statistic, P = .01), less decay in their nonbridge relations (-2.0 test statistic, P = .05), and they are more likely to acquire new bridge relations (2.3 test statistic, P = .03).[8]

The first two rows contain the observations used in the event-history analysis of decay (e.g., 1,561 bridges cited last year are not cited this year in the above table and at the bottom of Table 2). The third row contains new relations, which includes the 3,835 relationships first cited in the second panel (Table 2), the 1,545 first cited in the third panel (Table 2), and 2,229 first cited in the fourth panel (footnote 2).

[6]Predict peer evaluations and compensation from Models I and II in Table 1, excluding the count of bridge relationships. Compute residuals. A banker is in the low-performance category if she had an average peer evaluation lower than predicted by her job rank and tenure, or if his log average compensation was lower than predicted by his job rank and tenure. Of the 345 bankers, 205 fall into the low-performance category (59%).

[7]Let N1 be the number of times that a banker had a bridge continue from one panel to the next, N2 be the number of times that she had a nonbridge continue from one panel to the next, and so on up through N8 for the number of times that the banker cited a new contact who was connected with someone already in the banker's network. Taking the continuation of nonbridges as a reference point, network-change predictor 1 is the relative frequency with which bridges continue in a banker's network, N1/(1+N2). Predictor 3 is the relative frequency with which bridges became nonbridges, N3/(1+N2), and so on for a total of seven network-change scores for a banker.

[8]I get similar results if I replace the count of bridges predicting peer evaluations and compensation in Table 1 with counts of the network changes in Figure 3. Holding job rank and tenure constant (Model I in Table 1), bankers who receive low peer evaluations live with higher rates of decay in their bridge and nonbridge relations (t-tests of -4.0, P < .001, and -2.4, P = .02). The association

Decay Factors

Table 4 adds to the decay functions in Figure 2 distinctions between kinds of bankers and kinds of banker networks. Models VI and VIII replicate the Figure 3 conclusion that decay is associated with low-performance. Job rank and tenure in Table 3 are from Table 1. High-performance bankers are distinguished as in Figure 3. The decay of bridge and nonbridge relationships is less likely for high-performance bankers. I get the same result if I replace the high-low performance dichotomy with the continuous measures in Table 1 of peer evaluation or compensation.

——— Table 4 About Here ———

The broader structure of a banker's network matters in several ways. The most consequential is autocorrelation: Bridges and nonbridges are more likely to decay in networks where other relationships are decaying. The predictor "decayed contacts" in Table 4 is the number of decayed bridges (change E in Figure 3) and nonbridges (F in Figure 3) in a banker's network — relative to the number of continuing nonbridges as a reference category (footnote 7). The strong positive test statistics predicting decay in bridges (Model VII) and nonbridges (Model IX) show that decay spreads between relations in the same network. There are tendencies, not reported in Table 4, for decay diffusion to be more likely between similar kinds of relations. Bridge decay is more likely in a network where other bridges are decaying (not reported in Table 4, the test statistics are 3.3 versus 2.5 for the number of bridges decaying in a network separate from nonbridges). Nonbridge relations exist in clusters so it is not surprising to see higher autocorrelation for them (test statistics of 1.2 versus 3.6 for the number of bridges decaying in a network separate from nonbridges).

Autocorrelation accounts for some of other decay associations. One is the link between decay and growth. If bankers more subject to decay compensate with the

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with new bridge relations is weak (1.7 t-test, P = .08), but peer evaluations are not independent of the five non-decay predictors unless the association between peer evaluations and acquiring new bridge relations is allowed ($F_{5,334}$ = 2.95, P = .01, drops to an acceptable $F_{4,334}$ = 1.34, P = .25). Also, holding job rank and tenure constant (Model II), bankers paid less than their peers have higher rates of decay (t-tests of -3.6 for bridges, P < .001, and -2.7 for nonbridges, P = .01). The association with new bridges is weak (1.9 t-test, P = .06), but again, compensation is not independent of the non-decay predictors unless the association with new bridges is allowed ($F_{5,334}$ = 4.27, P = .001, drops to an acceptable $F_{4,334}$ = 1.23, P = .30).

acquisition of new contacts, then there should be a positive association between decay and new contacts. The association exists in the bottom row of Table 4 for Models VI and VIII. The predictor "new contacts" is the relative number of new bridges (change G in Figure 3) and new nonbridges (H in Figure 3) added to a banker's network over the time period. Both kinds of new contacts have similar associations with decay in bridges and nonbridges. The association between growth and decay disappears, however, when "decayed contacts" are held constant (Models VII and IX). Autocorrelation has the stronger association with decay.

Distinctions between kinds of bankers are another spurious correlate of decay. When "decayed contacts" are held constant in Models VII and IX, none of the banker attributes are associated with decay. In particular, the previously strong association with banker performance in Models VI and VIII disappears. The conclusion remains true with performance replaced by peer evaluation, alternative measures of compensation (e.g., average year or best year), or alternative functional forms for association with job rank (e.g., exponential increase with increasing rank). Decay is concentrated in the networks of low-performance bankers, so banker performance is an indirect measure of the aggregate decay in a network. Hold that aggregate decay constant as in Models VII and IX, and the risk of decay in any one relationship is independent of banker performance.

Bridge experience counteracts the autocorrelation in decay. In Models VI and VII, bridge decay is less likely in a network that contains continuing bridges (change A in Figure 3) or bridges that become nonbridge relationships (C in Figure 3). Decay is independent of new bridges emerging from what were nonbridge relationships. If I replace the seven network-change predictors in Model VII with the simple count of bridges used in Table 1, I get the strong negative association with bridge decay (-4.1 test statistic, $P < .001$).

Conclusion

I conclude that social capital accrues to those who already have it. In this population of bankers, bridge relations are social capital associated with more positive peer evaluations and higher compensation (Table 1). A higher rate of decay in bridges could be predicted with several lines of social science theory — my relationship with you is more likely to endure for several reasons if we have mutual friends. But there is also reason to expect that people would work to preserve relationships that provide cash and career advantages, so it is striking to see how rapidly bridge relationships decay despite their strong association with banker reputations and compensation. Nine in ten bridge relations cited this year are gone next year. Surviving relationships are less subject to decay (Figure 2). The liability of newness is more pronounced in bridges. Bridge relationships decay more quickly than nonbridges in their first two years. By the fourth year, both are down to the same number of survivors: one in a hundred. Thereafter, bridges decay more slowly than nonbridge relations.

So, the key to bridge survival is to make it past the high death rate in new bridges. The implication is that people rich in the social capital of bridge relations have to work hard to maintain their social capital. They could work on acquiring new contacts in other groups at a rate that compensates for bridge decay, or they could work on preserving bridge relations to slow decay. The first strategy is not characteristic of the bankers: decay is independent of growth (Table 4). Nor is the phenomenon so simple as the second strategy. Consistent with the strategy, decay is less frequent in the networks of high-performance bankers (Figure 3, Table 4), but the association is due to autocorrelation. Decay spreads between adjacent relations in that it is more likely in networks where there is a higher volume of relations decaying. Holding constant the volume of decaying relations in a network, there is no direct association between decay rates and network growth, the age of nonbridge relationships, or rank, tenure, and performance distinctions between bankers (Table 4).

Experience matters. Decay in nonbridge relations is significantly less likely in the networks of bankers who have more experience with the transformation of relationships; bridges turning into nonbridge relations and vice versa. Here, experience is a matter of the banker being flexible about staying in a relationship as it moves between the alternative states of bridge and nonbridge. More central to social capital, bridge decay is significantly less likely in the networks of bankers who have more experience with bridges. This is consistent with laboratory results on people learning networks. People find it more difficult to see the structural holes in a network (Freeman, 1992) and those whose own networks contain bridges across structural holes more quickly learn new networks that contain structural holes (Janicik, 1998). In as much as bridges are social capital, and bridge relations are less subject to decay when they involve people more experienced with bridges, I conclude that social capital accrues to those who already have it.

Appendix: Kinked Decay Functions

There is evidence — contrary to Figure 2 — that bridge decay should have a kink in it. Although little is known about bridge decay because longitudinal network data beyond small groups have not been available for study, there is research on certain kinds of relations that are probably bridges. For example, marriage can be a bridge relationship between the network around the husband and the network around the wife. Employment can be a bridge relationship for the employee linking the network inside a firm with her network outside. Relations between organization can be bridges for people in an organization connected to people in another organization.

Whether any such relation is a bridge depends on the surrounding network structure. One of the classic network studies, Bott (1957), is about the degree to which a marriage is a bridge (when the husbands network does not overlap with the wife's, their marriage is a bridge across the two networks), and the segregated sex roles that develop in bridge marriages (see Burt, 1992, pp. 255-260, for an interpretation in terms of bridges and structural holes). Douthit (2000) finds the same pattern in employment. Segregated work roles are more likely when supervision is a bridge relationship in that the boss' contacts do not overlap with the employee's.

Regardless of whether they are network bridges per se, relations such as marriage, employment, and organizational relations are bridge-like in spanning a social boundary: Marriage spans gender and kinship boundaries. Employment and relations between organizations span the boundary around an organization.

The bridge-like quality of these relationships is useful to note because they do not show the continuously declining decay functions illustrated in Figure 2. They instead show kinked decay functions as illustrated in Figure 4a.

The "Probability of Switching Auditor" line in Figure 4a is from Levinthal and Fichman's (1988: Figure 1) study of auditor-client relationships. Decay is measured by the probability that a company switches from its current accounting firm to a new one. The companies include all major publicly traded corporations in the US (excluding financial firms), along with many smaller ones, and most do not switch auditors over the 14 years studied (low probabilities of decay in Figure 4a). The probability of switching in Figure 4a increases through the first few years with a new auditor, peaks at four years, then decreases. Baker, Faulkner and Fisher (1998: 165) run a similar analysis of relations with advertising agencies. Over the 23 years studied, the average relationship is about five years. The risk of a company discontinuing the relationship with a new agency increases through an initial period of years, after which the relationship is decreasingly subject to decay. Kogut (1989:184) runs a related analysis on a selection of joint ventures, and finds the risk of dissolution increasing for the first three years of a venture (cf. Deeds and Hill, 1998:156-157, who find increasing risk of decay in the first five years of biotechnology research alliances, using perceived opportunism as a measure of decay). Japanese joint ventures in the US, which can be expected to have stronger pre-contract endowments as discussed below, have a longer initial period of low risk that lasts beyond a decade (Hennart, Kim and Zeng, 1998:389).

——— Figure 4 About Here ———

The "Probability of Leaving Employer" line in Figure 4a is from Brüderl (2000: Figure 2) and shows the probability of a blue-collar worker in a West-German manufacturing plant quitting given his or her time on the job. The risk of quitting increases for a few months, peaks at about five months, and decreases thereafter (Farber, 1994, reports a peak for young American workers at about three months). Brüderl (2000: Figure 1) reports a decay function for cohabitation in West Germany that increases sharply to its peak at two to three years, then decreases as the couple continues to live together. The peak is a two to three years later for the probability of marriage ending in divorce, illustrated by the dashed line in Figure 4a, which is taken from Heaton's (1990:59) graph of divorce rates estimated from a national probability sample of Americans (cf. Diekmann and Mitter, 1984; Brüderl and Diekmann, 1995).

Kinked decay functions are evidence of a liability of adolescence, distinct from the continuously decreasing decay functions familiar as evidence of a liability of newness (Levinthal and Fichman, 1988; Brüderl and Schüssler, 1990; Fichman and Levinthal, 1991). The initial period of low, increasing decay risk is discussed as a honeymoon, after which decay follows its usual course of decreasing in more mature relationships, leaving a peak risk in the "adolescence" of the relationship life course.

No Evidence of Decay Kink in Banker Relations

In studying the decay of friendship and colleague relationships, I find no evidence of kinked decay. The shape of the decay function for bridges is different from the shape for nonbridge relationships, and the risk of decay is higher in certain kinds of relationships, but decay decreases continuously over time as illustrated in Figure 2. I have only four years of data on the bankers, but decay begins at a high rate, and drops precipitously across the initial years, so it seems likely that a liability of adolescence would be visible in the four years if it existed among the bankers.

A quick statistical test is available by adding years-squared to the prediction of decay in Figure 2. This was the way that positive and negative age dependence was measured initially in population ecology (see Burt, 1992:216-217, for discussion with respect to the social capital of structural holes, largely drawing on Hannan and Freeman, 1989), and it is what Baker, Faulkner and Fisher (1998:167-168) present as evidence of a kinked decay in relations with advertising agencies. Tendency for risk to increase in the early years is indicated by a positive effect for years (T in Figure 2), and decreasing risk in later years is indicated by a negative effect for years-squared. When both terms are entered in the Figure 2 models, I get no evidence of an initial period of increasing decay risk (-0.1 test statistic for bridge decay as T increases, 1.2 for decay in nonbridges).

A further check is to look at the highest-ranking bankers. If anyone can slow decay by identifying productive relationships it should be the highest-ranking bankers. Their broader access to information gives them an advantage in identifying able colleagues, and their higher visibility amplifies the reputation cost of bad relationships. Estimates for the Figure 2 models fit to data on the highest-level bankers, however, only shows the liability of newness reported in the text: Bridges and nonbridges decay through their initial years, bridges more quickly (-1.33 coefficient with -7.1 test statistic for bridges; -.57 and -8.4 respectively for nonbridges), and association with the time-variable T for a honeymoon period are negligible when T-squared is added to the models (-0.5 test statistic for bridge decay, 0.2 for decay in nonbridges).

Finally, I am reassured by what seems to be the same pattern of continuously decreasing decay in the few data available on friendship and social support over time: Initial decay rates are high, decreasing in more mature relationships. Averaging results across the studies reviewed in Burt (2000a, Figure 1), 61% of friendships and support relationships outside the family survive the first year, and 18% are cited again ten years later. If the initial decay rate were constant, less than one percent would have survived the decade. Stronger relationships are less subject to decay: 72% of social support relations with family survive the first year, and 33% are cited again ten years later (your sister continues to be your sister, but you need not continue to cite her as a source of social support). If the initial decay rate were constant, only 3.7% percent would have survived the decade.

Kink-Producing Endowments

Kinked decay functions are evident in certain kinds of relations (such as marriage, cohabitation, employment, and relations between organizations), but not in the colleague relationships analyzed in the text, nor, it would seem, in friendship, or social support relationships. The question is why. Useful here is Hannan's (1998: 127-135) discussion of factors responsible for age dependence. Decay differences can be attributed to endowments found in the relations showing kinked decay (Hannan, 1998:131): "Some get endowed with extensive financial and social capital, because their founders have great wealth, status, or political influence or because the social conditions of founding are favorable." Endowments are the initial stock of assets with which Fichman and Levinthal (1991:443-444) presume relationships begin: "In contrast to the emphasis in the literature on the liabilities of newness, we suggest that relationships can start with some initial stock of assets, which (depending on the particular context) can include favorable prior beliefs, trust, goodwill, financial resources, or psychological commitment. We propose that if a relationship starts with an initial stock of assets, the risk of the relationship dissolving at its inception is reduced, even if the initial outcomes of the relationship are unfavorable." Kinked decay functions happen when an endowed relationship's decay risk is low initially because of an immunity created by the endowment, increases as the immunity ends, then decreases with further duration (Hannan, 1998: 142).

Endowments in the text of the paper are assumed to continue over the life of a relationship, so they would not create a kinked decay function. In Figure 2, for example, relations from bankers to colleagues in other divisions of the firm are more subject to decay and that is a skill distinction likely to continue over the life of a relationship (7.3 test statistic). Productive mutual acquaintances and banker maturity both lower the risk of decay (-6.7 and -8.2 test statistics respectively), and both can be expected to increase over the life of a relationship.

In contrast, there are two kinds of endowments in kinked-decay relations that could produce kinked decay and are much less a feature of the banker relations. Exit barriers are one. Barriers would include investments that cannot be moved to a new relationship, reputation costs of being seen by potential new partners as unable to make relationships work, costs created by allies of the erstwhile partner, or legal regulations intended to slow exit. For example, a divorce settlement is required to exit marriage (cohabitation involves less formal, but still unpleasant, decisions about who gets what from the joint household), and conditions that clarify life after divorce lower the barrier to leaving a marriage (dual careers, available alternative partners, previous experience with divorce, no-fault divorce, lack of children; e.g., see White, 1990). Changing employers involves a variety of costs created by the loss of close colleagues, the search for new employment, the inconveniences of geographical mobility, learning the operations of a new company, and building relations with new colleagues. Switching to a new supplier involves all of the above plus the costs of lost financial, human, and social capital invested or created to make the prior relationship work. Exclusive contracts indicate a lack of ready alternatives, and exclusive contracts with advertising agencies show less decay, especially if the agency is in-house (Baker, Faulkner and Fisher, 1998). Scale and complexity are barriers to switching suppliers because a large, complex company requires more investment in helping a supplier understand company operations and the investment is not easily transferred to a new supplier — and large, complex companies are less likely to discontinue their relationship with a supplier (Levinthal and Fichman, 1988; Baker, Faulkner and Fisher, 1998).

Maturity is a second endowment. The kinds of relations that show kinked decay are endowed with maturity beyond their measured years. Consider marriage. As of the wedding day, a marriage contract begins that is at some risk over time of ending in divorce or separation. You are not officially at risk of divorce until the day you marry, so marriage date is an appropriate start-point for duration. With respect to network decay, however, the relationship ended by divorce did not begin on the wedding day. The relationship began when the couple first met and liked one another, which put them in the risk set for marriage and divorce. Some people marry soon after they meet. Others date for a while, then live together, and eventually marry. A great many relationships expire before marriage. In other words, marriage is a contractual phase in a longer-running relationship. Preceding the marriage decay function is a steep function as in Figure 2 that describes decay in the relationships which did not survive to a marriage contract (cf. Fichman and Levinthal, 1991:452).

Similarly, a relationship between two organizations does not begin on the day a contract is signed. The contract was preceded by people discussing a link between the organizations. Preceding the decay function for the interorganizational contractual relation is a steeper function describing decay in interpersonal relations with representatives of alternative vendors with whom contracts were never signed. In fact, the interpersonal backbone for inter-organizational relations is highlighted in a follow-up study of the auditor-client relations in Figure 4a. Seabright, Levinthal and Fichman (1992) report that company time with an auditor is negligible in predicting the switch to a new auditor. The key variable is the tenure of the Chief Financial Officer (or the average tenure of the audit committee). Change the senior executive who reports the audit, and the company is more likely to switch to a new auditor regardless of company time with the current auditor.

With respect to network decay, contractual relationships — such as marriage, employment, or relations between organizations — are by some unknown amount older than the time that has passed since the contract began. Whatever learning occurred in the pre-contract period is an endowment lowering the risk of decay during the contract.

The endowment is limited, which creates a kink in the decay function. Some amount of the learning acquired during a pre-contract relationship falls out of date or is rendered irrelevant by exogenous change. You knew her well when you lived together, but career, cash, and children took the two of you in different directions that led to divorce. Our previous advertising agency was perfect for our position in the market, but the market changed and with it our advertising department, which led us to our new agency. When the endowment expires, risk of decay increases to a point (the peak in the decay function), after which decay risk decreases as usual with age.

Three implications follow. One is that measures of pre-contract relationship are important control variables when predicting decay in contractual relations.[9] Two, exit barriers and pre-contract endowments mean that contractual relationships show decay rates lower than the rates for otherwise similar relationships. The rates for employment, marriage, and auditor-client relations are well under .05 in Figure 4a. These contractual relations were preceded by friendship, social support, and

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[9]Interpretation problems with the control variables can be anticipated, as illustrated by research on the link between cohabitation and divorce (see Smock, 2000:6-7, for review). Cohabitation preceding marriage was initially understood to be a period in which two people could get to know one another and so make a better-informed decision about whether they were a good match for marriage. Cohabitation turned out to increase the risk of divorce. Current understanding is that people who cohabit are a kind of person more prone to divorce. The cohabitation preceding marriage is no longer interpreted as a period of due diligence so much as revealed preference. The same conundrum can be anticipated for any measure of the endowment provided by a pre-contract relationship. For example, imagine a control variable that measures a company's due diligence on suppliers before signing with one. If the control variable has a negative association with decay in the subsequent supplier relationship, then the variable could be interpreted as an endowment improving the quality of the match between company and supplier. If the association turns out to be positive, the variable could be interpreted equally well as an indicator of the kind of people running the company — perhaps overly cautious people stuck in bureaucratic due-diligence processes, so of course they have trouble dealing with other organizations.

colleague relationships for which decay is a much higher risk: .72 and .86 for the banker colleague relationships in Table 2. The average one-year decay rate is .39 in friendship and social support beyond the family (Burt, 2000a: Table 1), which is an under-estimate of decay in new relations because the rate is an average across all relations cited in an initial survey, including long-term relationships in which decay is unlikely.

A third implication is that if control variables could be found sufficient to hold constant variation in endowments, then the low risk of decay during a honeymoon period could be expected to increase, and the peak risk during adolescence could be expected to move forward, such that decay would show the continuously decreasing decay illustrated in Figure 2 that defines the liability of newness. Levinthal and Fichman (1988:362-365) come close to the ideal with their analysis of audit qualifications. Auditors, like other providers of professional service, depend on reputation. When an auditor feels that a report does not conform to generally accepted accounting practices, the auditor can protect its reputation by putting qualifications on the report. Doing so is an indicator of exit-barrier and pre-contract endowments expiring within a relationship, or as Levinthal and Fichman (1988:364) put it: "Our interpretation is that a qualified opinion is an indicator of conflict within the auditor-client relationship." Holding constant the timing of audit qualifications takes the kink out of the decay function (Levinthal and Fichman, 1988:365): "When we controlled for the effect of qualifications, the hazard rate decreased monotonically with time."

Kinked Decay Ignored

In sum, I ignore kinked decay functions in the text for two reasons: First, there is no evidence of kinked decay in the panel data, so raising the issue would unnecessarily complicate the familiar liability-of-newness story. Second, there are two kinds of endowments in kinked-decay relations that could produce kinked decay and are not a feature of the banker relationships: (1) Barriers to exit from the banker relations must have been minimal given the high decay rates. (2) The high first-year decay rate sharply decreasing over years two and three provides no evidence of pre-observation due diligence lowering the risk of decay.

So why include this Appendix? If kinked decay is irrelevant to the banker data, why not relegate kinked decay to a footnote, or ignore it?

The Appendix puts the banker results in broader perspective, especially useful on the topic of network decay because of data limitations. There is value to linking longitudinal studies of contractual bridge relations with longitudinal studies of personal relations in large populations. Data on the former are more available, while results on the latter define baseline processes against which decay in contractual bridges can be better understood (despite process-obscuring endowments with which contractual relationships are encrusted by convention, corporate bureaucracy, and the law).

More, it is important to understand kinked decay because decay, in theory, must be kinked in all relationships. Etiquette is a kink-producing endowment common to interpersonal relationships. At the moment two people are introduced, there is some initial period during which it would be rude to break away. To be sure, etiquette is not a long-suffering endowment. The honeymoon period could be no more than the time it takes for the person to say hello. It could be no more than the duration of the program or seminar in which you meet one another. It could be the duration of the project in which you are both involved. Whatever the relationship, there is some initial period of time for which the risk of decay is zero. Therefore, all relationship decay must be kinked.

Moving from theory to practice, data limitations can obscure kinked decay. The honeymoon period that Brüderl reports in Figure 4a for blue-collar workers is five months. The banker relations are measured annually (as typically will be the case with such data since colleague evaluations are gathered in annual employee reviews). If Brüderl had been limited to annual data, the honeymoon period would not have been visible, and the decay function would have seemed to be continuously decreasing as in Figure 2.

The bankers in the text are remote from blue-collar workers, but it is credible to say that they have a short honeymoon period in new relations, so a honeymoon could come and go without being detected in annual data. In Figure 4b, I have displayed the Figure 2 decay functions with a projected kink in decay.[10] The risk of decay increases quickly after colleagues first meet, then declines after a peak. The risk peaks at 13 months for bridge relations, just after the first measurement interval. Nonbridge relations have a longer honeymoon period, with decay risk peaking at 22 months (illustrated, contrary to the liability of newness, by the modest decline in Table 2 from a first-year decay rate of .74 to a second-year rate of .72). The Figure 2 decay functions are visible in the annual data. The Figure 4b functions are not visible, but are possible if decay functions are assumed to be kinked. I can do nothing about the annual interval in the banker data except to note interval width as an issue to check in future research with shorter measurement intervals, especially during the first year. For the text of this paper, I put the issue aside as a non-issue in the absence of evidence to the contrary.

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[10] I use a two-parameter model to describe kinked decay: r(T) = (aT)exp(-T/b), where r(T) is the risk of decay at time T, and a and b are parameters, b the time of the peak in decay risk (see Diekmann and Mitter, 1984; Diekmann, 1999:787). If detailed data were available through the first year, I would want to separate level, shape, and time of peak decay (e.g., Brüderl and Diekmann, 1995:162), but the two-parameter model is sufficient for illustration here. Figure 4b is defined as follows: (1) I used the functions in Figure 2 to generate decay data. The probability of decay in a relationship at age T in Figure 2 is defined by the logit models in the figure: 1/[1 + exp(-3.377+1.222T)] for bridges, and 1/[1+exp(-1.556+.366T)] for nonbridges. The intercepts in these expressions are adjusted for means on the Figure 2 predictors other than T. I used the two expressions to define 91 quarterly decay rates for T equal 1.00, 1.25, 1.50, and so on through T equal 10. I added one observation to include an etiquette-induced zero decay rate for the first half-day of a relationship (0 decay rate for T equal to .5/365). (2) I used frequencies in Table 2 to weight the data. For bridges, two-year relations are about 10 times as frequent as three-year relations in Table 2, and one-year relations are about ten times the number of two-year relations. I gave the 92 bridge observations a weight of 1, except two-year bridges are weighted 10, and bridges a year or younger are weighted 100. For nonbridge relations, two-year relations are about four times as frequent as three-year relations in Table 2, and one-year relations are about four times the number of two-year relations. Weights for nonbridge observations are 1, 4, and 16 corresponding to the 1, 10, and 100 for bridges. (3) I used a nonlinear fitting algorithm (SYSTAT) to compute a and b in the two-parameter decay model and plotted the predictions in Figure 4b. For bridge relations, a is 2.183, and b is 1.096 years (which, times 12, would put the peak risk of decay at 13.2 months). For nonbridge relations, a is 1.104 and b is 1.865 (which would put the peak decay risk at 22.4 months).

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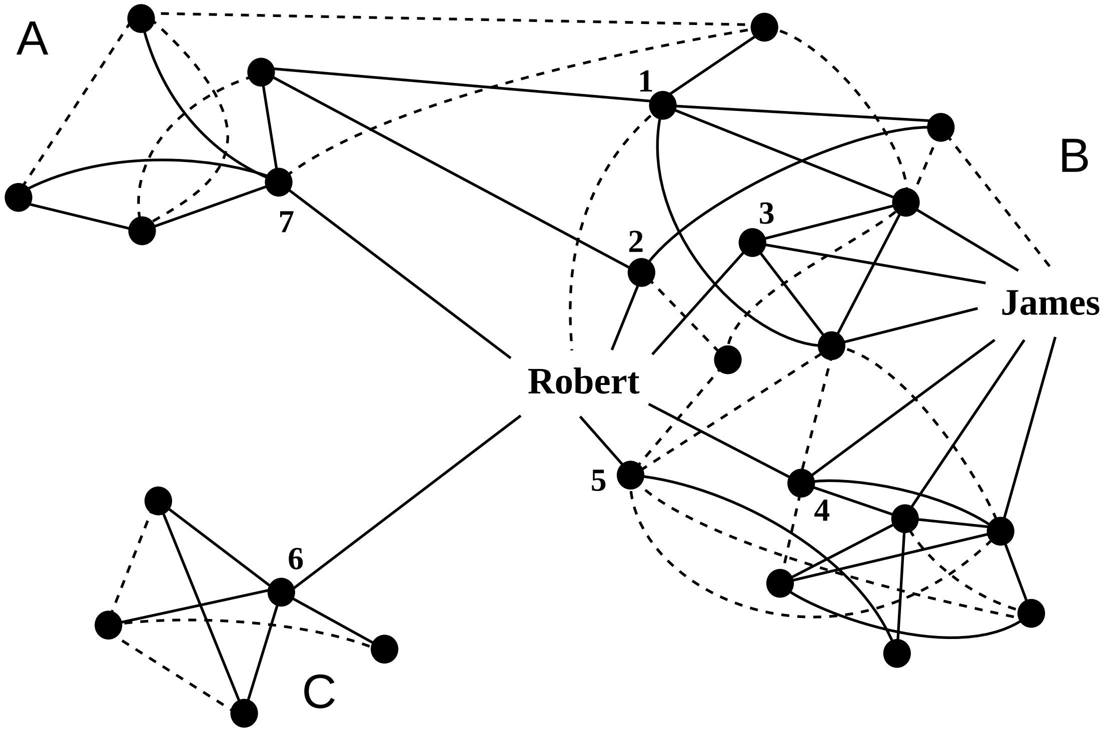


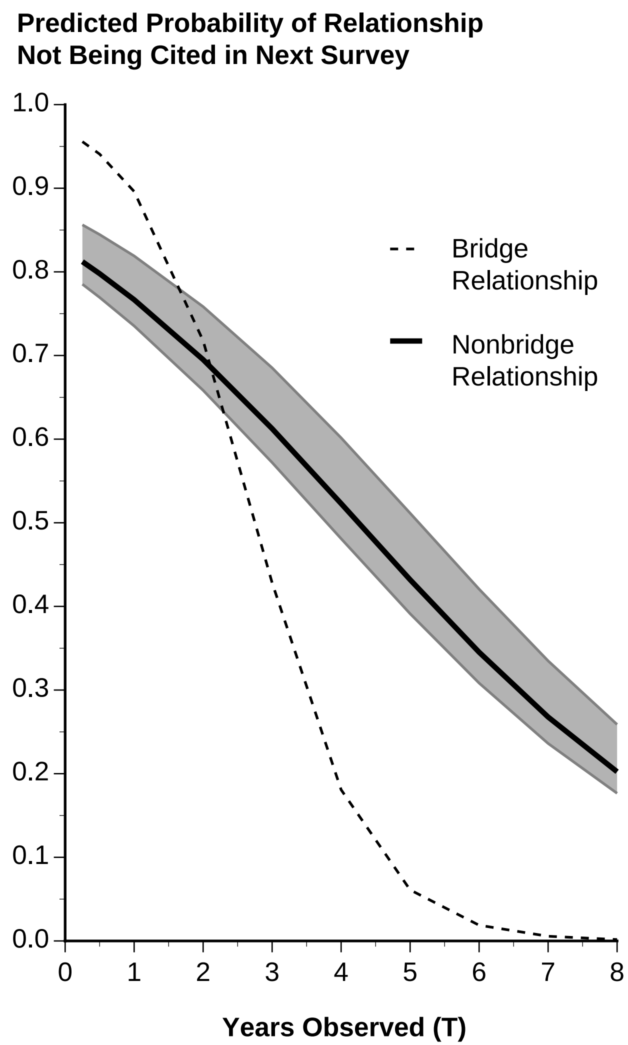
Density Table of Relations Within and Between Groups

.65			Group A (5 people and 8 ties; 5 strong, 3 weak)
.05	.25		Group B (17 people and 41 ties; 27 strong, 14 weak)
.00	.01	.65	Group C (5 people and 8 ties; 5 strong, 3 weak)

Figure 1.
Social Capital and Bridges across Structural Holes.

Figure 2. Predicting Decay.

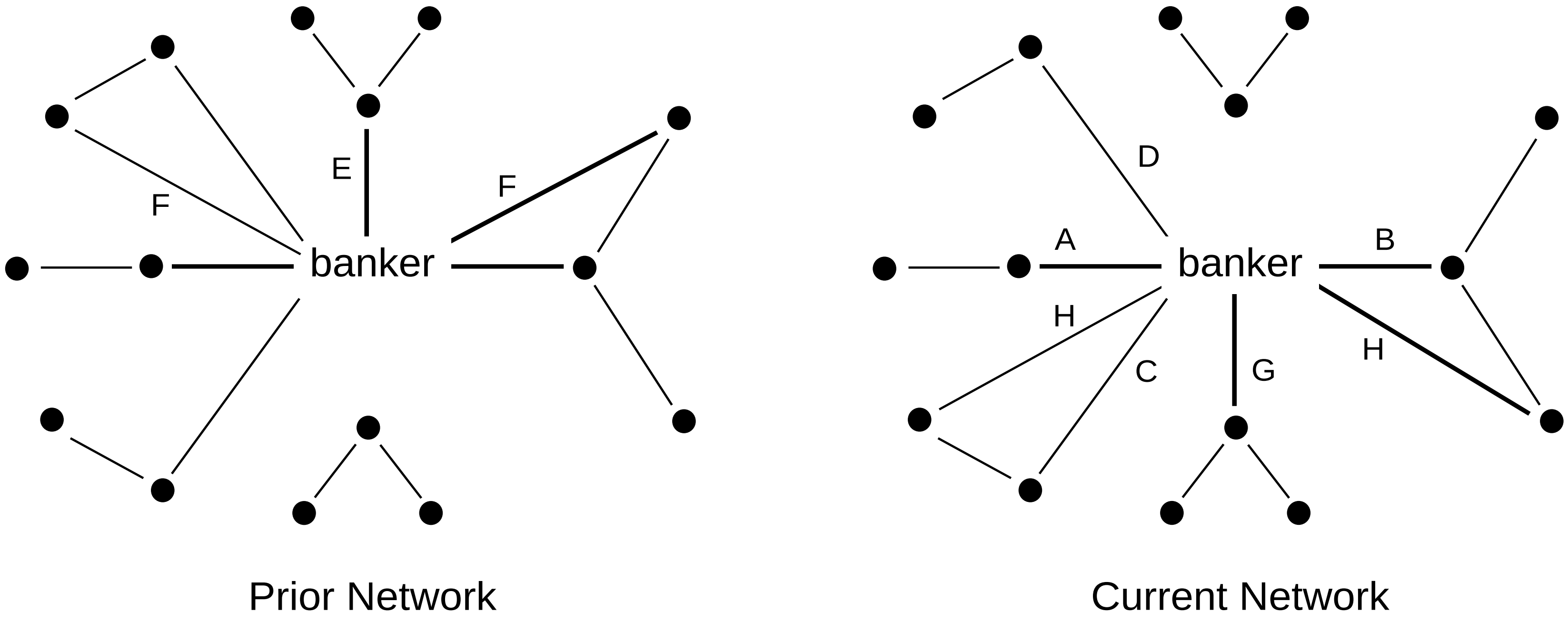
	Bridge Relationships	Nonbridge Relationships
Intercept	5.259	3.121
Marginals in year T (cites from banker times cites to colleague)	-.0007 (-5.2) **	-.0006 (-6.7) **
Local Structure:		
Prior relationship positive	-.150 (-0.7)	-.255 (-4.8) **
Prior relationship negative	-.066 (-0.3)	.024 (0.4)
Colleague not in banking division	.111 (0.7)	.366 (7.3) **
Number of positive TP ties	——	-.061 (-6.7) **
Number of negative TP ties	-.093 (-1.6)	.013 (1.0)
Liability of Newness:		
Years observed (T)	-1.222 (-7.3) **	-.366 (-5.9) **
Panel in which first cited (P)	-.774 (-6.5) **	-.487 (-8.2) **
Chi-Square	104.4 **	341.9 **
Number of Observations	1,809	20,900



NOTE — These are logit coefficients predicting decay with test statistics in parentheses (standard errors are adjusted for autocorrelation between relations cited by the same respondent, e.g., Kish and Frankel, 1974). Decay occurs if relationship cited in year T-1 is not cited in year T. Unless otherwise indicated, predictor variables are measured for year T-1. “TP ties” refers to indirect connections via third parties.

* P < .05 **P < .001

Figure 3. Change in the Banker Networks.



High-performance bankers (%)	Low-performance bankers (%)	Logit test statistic	N	Changes from prior to current network
70	30	0.8	127	A. continuation: bridge
64	36	—	5,030	B. continuation: nonbridge
65	35	-0.1	121	C. transformation: bridge to nonbridge
65	35	0.6	756	D. transformation: nonbridge to bridge
48	52	-3.0	1,561	E. decayed bridge
46	54	-2.0	15,114	F. decayed nonbridge
58	42	2.3	1,403	G. new bridge (enter cluster)
62	38	0.8	6,206	H. new nonbridge (leverage from prior contacts)

Figure 4. Kinked Decay Functions.

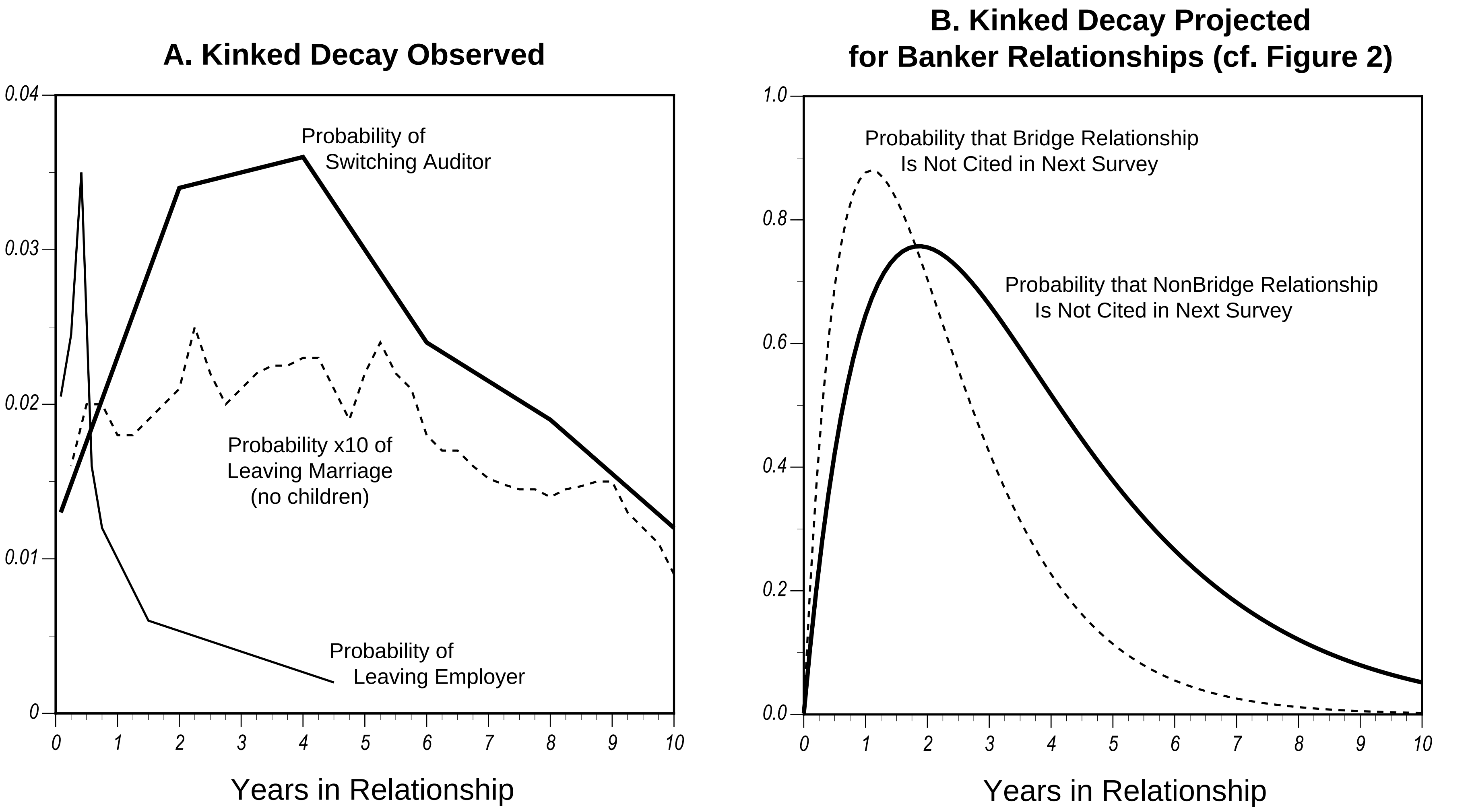


Table 1.
Bridges and Banker Performance.

	means	Peer Evaluation	Log Compensation		Exit from Company	
		I	II	III	IV	V
R^2		.106	.696	.740	——	——
Constant		3.093	1.813	.119	-.651	8.107
Job Rank	2.309	-.254	-.181	-.042	1.343	.859
		(-2.9) *	(-1.5)	(-0.4)	(2.2) *	(1.2)
Rank x Rank	6.959	.060	.154	.120	-.353	.004
		(3.5) **	(6.1) **	(5.1) **	(-2.7) *	(0.0)
Tenure (years/10)	.817	.003	-.266	-.267	.385	-.221
		(0.1)	(-5.6) **	(-6.1) **	(1.7)	(-0.8)
Number of bridges in banker's network	7.983	.008	.016	.012	-.075	-.034
		(3.5) **	(4.9) **	(3.8) **	(-4.1) **	(-1.7)
Peer evaluation	2.996	——	——	.547	——	-1.521
				(7.6) **		(-3.5) **
Log compensation	2.545	——	——	——	——	-2.257
						(-6.1) **

Note — Row variables predict the column variables for 345 bankers pooled across the four panels. Metric coefficients are presented with test statistics in parentheses. Models IV and V are logit models with chi-square statistics of 42.6 and 132.8 (4 and 6 degrees of freedom). * P < .05 ** P < .001

Table 2.
Bridges Decay Faster.

Years observed (T)	Panel in which first cited (P)	Bridge Relationships			Nonbridge Relationships		
		Relationships at risk[d]	Relationships that decay[e]	Decay rate[f]	Relationships at risk[d]	Relationships that decay[e]	Decay rate[f]
1	1[a]	801	720	.90	11,854	8,806	.74
2	1[a]	81	66	.81	3,048	2,180	.72
3	1[a]	15	6	.40	868	461	.53
1	2[b]	670	608	.91	3,165	2,565	.81
2	2[b]	62	40	.65	600	358	.60
1	3[c]	180	121	.67	1,365	784	.57
TOTAL		1,809	1,561	.86	20,900	15,114	.72

Note — (a) This row describes colleague relationships cited in the first panel. (b) This row describes relations cited in the second panel, but not in the first panel. (c) This row describes relations cited in the third panel, but not in the second. (d) These are the relations cited this year that are at risk of not being cited next year. (e) These are the relations at risk that were not re-cited. (f) This is column (e) divided by (d), the proportion of relations at risk that were not re-cited. The 1,809 bridge relationships connect bankers and colleagues who have no third parties through whom they have a positive indirect connection.

Table 3.
Expected Survival of 100 Relationships

Tie Age (T)	Banker-Colleague, with Controls		Banker-Colleague, and Other Relations, without Controls		
	Bridges	Nonbridges	Banker-Colleague	Nonkin Social	Family
0	100.0	100.0	100.0	100.0	100.0
1	10.4	23.3	32.1	60.9	72.4
2	2.9	7.1	13.7	45.5	59.9
3	1.7	2.8	7.4	37.1	52.4
4	1.4	1.3	4.8	31.6	47.2
5	1.3	.7	3.5	27.7	43.4
6	1.3	.5	2.9	24.8	40.4
7	1.3	.4	2.5	22.6	37.9
8	1.3	.3	2.3	20.7	35.9

Note — The predictions for banker relations to colleagues, controlling for decay factors other than tie age, are taken from Figure 2 using mean scores on the decay factors within each category of relationships. Predictions are based on decay rates at the end of each year. Predictions for the other three columns of the table are taken from survival functions in Burt (2000a: Figure 1A).

Table 4.
Decay Factors.

	Bridge Relationships VI	Bridge Relationships VII	Nonbridge Relationships VIII	Nonbridge Relationships IX
Intercept	5.271	3.552	2.888	.628
Marginals in year T (cites from banker times cites to colleague)	-.0005	-.0003	-.0007	-.0003
	(-4.8)**	(-3.3)*	(-5.3)**	(-4.3)**
Local Structure:				
Prior relationship positive	-.173	-.138	-.271	-.256
	(-1.7)	(-1.3)	(-7.5)**	(-9.5)**
Colleague not in banking division	.124	.147	.356	.370
	(0.8)	(1.0)	(7.1)**	(7.6)**
Number of positive TP ties	——	——	-.069	-.081
			(-8.4)**	(-11.9)**
Liability of Newness:				
Years observed (T)	-.649	-.424	-.289	.165
	(-3.3)**	(-2.1)*	(-4.7)**	(2.2)*
Panel in which first cited (P)	-.711	-.450	-.449	-.059
	(-5.8)**	(-3.4)**	(-7.5)**	(-0.8)
Kinds of Bankers:				
Job rank	-.116	-.084	.072	.097
	(-1.3)	(-1.0)	(1.4)	(1.7)
Tenure (years/10)	-.219	-.235	.186	.094
	(-1.5)	(-1.9)	(2.0)*	(1.9)
High-performance banker	-.339	-.027	-.449	-.097
	(-2.1)*	(-0.2)	(-4.3)**	(-1.2)
Banker Networks:				
A. Bridge → Bridge	-3.841	-3.620	-1.561	-.037
	(-4.0)**	(-3.7)**	(-2.2)*	(-0.1)
C. Bridge → Nonbridge	-5.127	-5.117	-1.462	-1.382
	(-4.2)**	(-4.5)**	(-2.1)*	(-3.5)**
D. Nonbridge → Bridge	.220	-.118	-.265	-1.339
	(0.6)	(-0.2)	(-1.2)	(-3.7)**
E & F. Decayed contacts	——	.253	——	.265
		(4.4)**		(3.9)**
G & H. New contacts	.131	-.071	.149	.007
	(2.1)*	(-0.9)	(4.1)**	(0.1)
Chi-Square	169.8**	178.7**	493.6**	816.9**
Number of Observations	1,809	1,809	20,900	20,900

NOTE — These are logit coefficients predicting decay with test statistics in parentheses (standard errors are adjusted for autocorrelation between relations cited by the same respondent, e.g., Kish and Frankel, 1974). Decay occurs if relationship cited in year T-1 is not cited in year T. Unless otherwise indicated, predictor variables are measured for year T-1. "TP ties" refers to indirect connections via third parties.

* P < .05 **P < .001