SMALL BUSINESS ALLIANCES: PROFESSIONAL NETWORKS AND INNOVATION ADOPTION

HONGSEOK OH
Department of Management of Organizations
School of Business and Management
The Hong Kong University of Science and Technology
Clear Water Bay, Kowloon, Hong Kong
Tel: (852) 2358-7738; Fax; (852) 2335-5325; E-mail: mnhongoh@ust.hk

MARTIN KILDUFF
Department of Management and Organization
Smeal College of Business Administration
The Pennsylvania State University
403 Beam Business Administration Building
University Park, PA 16802, U.S.A.
Tel: (814) 865-9822; Fax (814) 863-7261; E-mail: mkilduff@psu.edu

CHARLIE O. TREVOR
Department of Management and Human Resources
College of Business
The University of Wisconsin-Madison
4113 Grainger Hall
Madison, WI 53706-1323, U.S.A.
Tel: (608) 262-7920; E-mail:ctrevor@bus.wisc.edu

November 2000
SMALL BUSINESS ALLIANCES: PROFESSIONAL NETWORKS AND INNOVATION ADOPTION

Social network theory and new institutional theory have suggested that in some industries organizations are embedded in networks of interacting individuals who escape the iron cage of institutional practice by creating webs of informal relationships connecting relatively homogeneous units. In this study, we examined the importance of informal relationships within industry groupings of small medical practices for the adoption of new technology. Analysis showed that the capacity to recognize and quickly adopt promising new technology depends not only on ensuring that key personnel receive up-to-date training and continuing access to new scientific developments, but also on the social networking skills of key decision makers. Particularly striking was the interaction between internal and external factors. Organizations whose key personnel had less up-to-date training were more affected by their structural position in the industry network. This suggests that organizations can partially offset the inertia that comes with age by harvesting new information from disparate parts of the network. This perspective on organizational learning emphasizes the importance of both internal expertise and external scanning. To keep up with the rush of new technology, the organization needs to develop internally the ability to evaluate new developments, but should not neglect the network benefits of a brokerage position in the relevant industry.

Key Words: Social networks, innovation, organizational learning, profession
The strategy literature typically assumes that organizations in the same business niche compete for customers, particularly if the organizations are geographically proximate. Where strategic alliances between organizations exist, these are usually forged between focal organizations and critical resource suppliers rather than with direct competitors (Gulati, 1998). But within industry groups, there are often social interactions between people from companies that compete directly (see Liebeskind et al, 1996 and Powell, Koput, & Smith-Doerr, 1996 for the case in the biotechnology industry). For example, in Silicon Valley, employees of different organizations tend to share information with trusted friends, paying little attention to the sacrosanct boundaries of formal organization (Saxenian, 1990). Indeed, the new institutional theory suggests that, as a general principle, formal organizational boundaries are becoming less important. Government regulations, professional socialization, and taken-for-granted operating procedures render organizations remarkably similar in the modern world (DiMaggio & Powell, 1983). From this perspective, people are bound together not as employees of distinctive organizations, but as members of the same industries or professional associations (Abbott, 1988; Barley & Tolbert, 1991).

One of the industries in which such institutionalized practices are pervasive is the health industry. Doctors are socialized in medical schools to take for granted certain axioms concerning medical practice. Widespread federal, state, and local regulations insure that physician organizations are remarkably similar. Physicians, belonging as they do to the same profession, interact across organizational boundaries as professional colleagues, linking organizations together. In this sense, medical practice is embedded in networks of interacting
physicians who escape the iron cage of institutional practice (cf. DiMaggio & Powell, 1983) by creating webs of informal relationships connecting relatively homogenous units.

Social network theorists have long emphasized the importance of friendship and other informal networks as pathways along which resources such as information, advice, and intellectual capital flow (Granovetter, 1985). But this emphasis on informal relations has often been ignored in favor of research that looks at economic relations embedded in more formal types of relationships such as interlocking directorates (see Uzzi, 1996, for an exception). In our research, we examine the importance of informal relationships within industry groupings of small medical practices for the adoption of new technology.

**THE ADOPTION DECISION**

A distinction is often drawn between organizations that produce innovations themselves, and organizations that adopt innovations developed elsewhere (Fiol, 1996). To some extent, however, all organizations are adopters of new technology because no organization can invent everything it needs to do business. As March and Simon (1958: 188) pointed out, "most innovations in an organization are a result of borrowing rather than invention." Thus, the question of why some organizations adopt promising technology early rather than late is of interest to decision makers in all organizations. Our focus, then, is on the adoption of new technology rather than on its development.

Previous research has identified three main influences on organizations' propensity to adopt innovation. Researchers in the first stream have argued that older organizations tend to be more structurally inert, more resistant to change (Hannan & Freeman, 1984; Stinchcombe, 1965), and therefore less likely to adopt innovations (Kimberly & Evanisko, 1981). Applying this idea
to the case of small medical practices, we take the recency of training of physicians attached to the practice to be the most important aspect of organizational age related to innovation adoption (cf. Meyer & Goes, 1988). Medical practices staffed by relatively new doctors are likely to be less inert, less steeped in relatively taken-for-granted scripts and schemas built up over the years, and, therefore, more open to innovation adoption.

Researchers in the second stream have highlighted the internal capacity of organizations to assess the potential of new technology (Cohen & Levinthal, 1990; Dewar & Dutton, 1986; Glynn, 1996). For example, Glynn (1996) introduced the concept of "organizational intelligence" to capture the relative capacity of organizations to recognize and process available information about new technology. Similarly, Cohen and Levinthal (1990) suggested that the greater the organization's internal expertise the greater the absorptive capacity, defined as the organization's ability to absorb new related knowledge from the external environment. Again, applying this research to the case of small medical practices, we expect that organizations with only one resident physician would have less absorptive capacity than medical practices with more than one physician. In the case of medical practices, the intelligence of the organization, its absorptive capacity, consists of the highly-trained capacities of its medical personnel.

Researchers in the third stream have focused on how structural patterns in industries affect organizations' adoption decisions. These researchers have identified the scope and rate of innovation diffusion across organizations, and thus shed light on the importance of external network ties in the adoption of new technology (Abrahamson, 1991; Attewell, 1992; Coleman, Katz & Menzel, 1966; Valente, 1996). According to this approach, through interactions with prior users in the same social network, potential users of new technology are informed about its
availability and are persuaded to adopt it (Rogers, 1983). We build on this research to emphasize the importance of network position in the informal network of collegial interaction between medical professionals.

Despite the relevance of these approaches to research on the adoption of new technology, researchers have seldom considered all three approaches simultaneously. Further, the results of research from each approach have been inconsistent, and the overall findings in the area of innovation adoption have failed to accumulate (Downs & Mohr, 1976; Fiol, 1996; Wolfe, 1994). We take an organizational learning perspective (Huber, 1991) in integrating insights from each research stream. From our perspective, organizations acquire knowledge from both direct and vicarious experience, interpret this knowledge, and build inferences from this interpretation into routines that guide behavior (Levitt & March, 1988). Thus, we suggest that innovation adoption is likely to be influenced by three factors: (a) organizational age; (b) the absorptive capacity of the organization in terms of its ability to recognize and evaluate new technology; and (c) the location of the organization in the social network of connections across the industry.

Moving beyond examining these three factors as independent predictors of innovation adoption, we also expected to find an interaction between two of the factors: organizational age and network position. New organizations are likely to adopt promising new technology relatively quickly because these organizations are not subject to strong inertial forces. These new organizations (compared to older organizations) may have less recourse to networks of informal industry contacts to validate adoption decisions. Older organizations, by contrast, are likely to be more resistant to adoption decisions and more reliant on trusted network confidants for information concerning which innovations to adopt.
To investigate the influences of these factors on organizations' adoption decisions, we examined technological responsiveness in the medical industry. Technological innovation is a constant in the medical field (Bell, 1989), and the question of which new product or technique to adopt is one faced almost daily by medical decision makers who must juggle reputed benefits, possible side-effects, cost and efficiency tradeoffs, and fit with existing knowledge bases. In the current research, small medical practices in the Midwest were faced with the possibility of adopting a powerful new prescription antibiotic drug useful over a wide variety of medical conditions and for which there were few alternatives (see the discussion in Burt, 1987: 1298). Eventually this drug, tetracycline, came to be universally adopted by medical practices as a standard remedy. The question we try to answer is: Why did some organizations adopt the innovation earlier than others?

RESEARCH BACKGROUND

The data we analyze in this paper concern private medical practices in four neighboring Illinois cities (Peoria, Bloomington, Quincy and Galesburg) in the mid-1950s. This area was chosen as a research site in part because of the absence of a large medical center (Coleman, Katz, & Menzel, 1966: 17). In the 1950s, such medical centers were encroaching on the autonomy physicians in private practice had fought for throughout the twentieth century, an autonomy to treat patients free from interference from third-party entities. Private-practice physicians represented by the American Medical Association (AMA) had, for example, in 1934 argued strongly against the reduction of physicians to mere “employees” whose services could be “peddled as commodities” by “third party” owners (quoted in Starr, 1982: 217). The main issue for the AMA was that no third party should make a profit from the services rendered by a
Physician to a patient. Physicians also resisted attempts to legislate socialized medicine, which they also saw as interfering with market freedom. For example, the AMA responded to President Truman’s universal health insurance scheme with the claim that the scheme would make doctors “slaves” (Starr, 1982: 282). The fierce opposition of the AMA (including a national educational campaign costing $2.25 million in 1950) helped to defeat the plan. Private practitioners championed capitalism over what they denounced as a rising socialist tide: “Many doctors’ offices became outposts in a political struggle, dispensing literature, cartoons, and other propaganda against ‘socialized medicine’” (Starr, 1982: 288).

The mid-1950s were a time of tremendous expansion of medical services coupled with revolutions in treatments. Medical services in major urban areas were increasingly dominated by university-based medical centers such as Columbia-Presbyterian in New York City with affiliated medical and dental schools as well as schools of pharmacy, public health, and nursing: “Universities became the umbrella organizations for America’s regional medical centers, which instead of being organized around the needs of patients, were oriented primarily toward research and training” (Starr, 1982: 361). These spreading empires threatened to reduce physicians to employees who “rarely had any long-term relations” with patients (Starr, 1982: 362).

In this context, private medical practices offered medical care that was strongly oriented not toward research but toward the needs of patients, who paid the bills. Physicians in private practice “depended more on the good will of patients than did institutionally based physicians” (Starr, 1982: 362). With the rapid expansion of post-war demand for health services of all kinds, private medical practices in the mid-1950s “were doing far better economically than ever before….Theirs was a sellers’ market” (Starr, 1982: 362).
With increasing innovations in medical treatments coupled with increasing demand for services, private medical practices depended not just on the good-will of their customers but also on the cooperation of professional colleagues for referrals, staff privileges at local hospitals and malpractice defense (Starr, 1982: 362). The physicians in private-practices in any particular community were highly interdependent, not least because they needed help in assessing the flood of new treatments and technologies appearing on the medical market.

In using the medical innovation data (Coleman et al., 1966), we took as our unit of analysis the private medical practice comprising of one, two or more physicians. The data included only medical practices in the private sector, eliminating physicians employed in hospital institutions. Previous research using this data set has ignored the warning of those who collected this data that, “the individual doctor is not the most relevant unit of analysis in studying the reaction of these communities to the new drug” (Coleman et al., 1966: 82). Although the data set has been recognized as representing patterns of adoption by organizations in the medical industry (e.g., March & Simon, 1958: 189), researchers (e.g., Burt, 1987; Marsden & Podolny, 1990; Strang & Tuma, 1993) have treated individual physicians as independent decision makers. In contrast, we explicitly take into account the fact that many of the individual physicians in the data set practiced not as individuals but as members of small medical practices. Thus, our unit of analysis is not the individual physician, but the medical practice consisting of one or more physicians. The original researchers were emphatic in declaring that their study aimed to shed light on “how important parts of society – producer and consumer, government and public – are tied together” (Coleman et al., 1966: 6). We emphasize in this paper this original focus on the macro-structural aspects of organizational adoption.
The present study, therefore, concentrates solely on a community of interdependent private practices. These practices in the mid-1950s were flourishing as never before in terms of revenues. However, the autonomy of these medical practices faced worrying threats from both the growing reach of medical empires based in university medical centers and from recurrent government attempts to legislate universal health care.

**THEORY AND HYPOTHESES**

Small medical practices, like all organizations, are repositories of tacit knowledge, skills, and routines (Nelson & Winter, 1982; Stinchcombe, 1965). These built-in competencies can be difficult to change (Hannan & Freeman, 1984) especially if they have proven successful in helping the organization survive and compete (Cooper & Schendel, 1976). Thus, new and better routines may be difficult to learn if organizations have experienced success with existing routines (Levitt & March, 1988). Additionally, personnel in organizations who have been successful with one set of tools may resist changing to another set of tools. Research on medical organizations has shown that new technology can disrupt established routines and disempower those trained in out-moded methods (Barley, 1986). Decision makers trained in relatively old routines are likely to resist adopting new technologies that are unfamiliar and that threaten their status. For example, small medical practices run by physicians with relatively old training may be slower in adopting promising new innovations than small medical practices run by physicians with relatively recent training. As discussed above, the recency of training in these small medical practices represents the age of organization. The older the organization, the slower the medical practice will adopt new technology due to structural inertia and subsequent resistance to change (Stinchcombe, 1965; Hannan and Freeman, 1984).
Hypothesis 1: The more recent the medical training of the medical practices’ physicians, the quicker the medical practice will be in adopting useful new technology.

Organizations also differ in their ability to recognize and evaluate new environmental developments such as innovative drugs. Organizations that possess relevant prior skills or contextual knowledge tend to have a better understanding of new technology (Cohen & Levinthal, 1990). For a small organization reliant on the professional skills of one person, the addition of another highly skilled professional can make a profound difference in the learning capacity of the organization. As Weick (1979: 237) has suggested, one of the crucial transitions in any organization is the growth from one person to two. In terms of Weick’s (1979: 238) organizing model, an organization of two people has more potential solutions to problems than an organization of one person. An organization of two physicians has more capacity to scan the environment and recognize new developments than an organization of only one physician: The absorptive capacity of the organization is effectively doubled by adding another highly trained diagnostic expert. Previous research has recognized the degree to which the actual number of highly trained professionals can represent the depth of knowledge resources that the organization can draw upon (cf. Dewar & Dutton, 1986). From this perspective, therefore, the absorptive capacity of small professional organizations (such as medical practices formed around one, two, or three physicians) can be measured as the number of professionals in the organization. It is these professionals who represent the capacity of the organization to absorb knowledge. The higher this absorptive capacity, the quicker useful new technology is likely to be adopted.

Hypothesis 2: The higher the absorptive capacity of the small medical practice, the quicker it will adopt useful new technology.
Some organizations, therefore, are able to adopt beneficial technologies more quickly than their rivals because they have more technological expertise. However, organizations are not limited to internal systems of appraisal in deciding whether to adopt new technology (Pennings & Harianto, 1992a; 1992b). One of the important roles of top managers is to develop and maintain a network of contacts outside the organization (Mintzberg, 1971; 1973). Organizations are tied to other organizations in the industry through the personal networks of organizational members. Many decision makers are awash in new product recommendations from a variety of sources. Decision makers rely on external networks of trusted confidants to help alert them to important new developments that otherwise might be difficult to discern.

Moreover, because the consequences of important strategic decisions, such as the adoption of new technology, are uncertain, decision makers tend to examine the actions of other organizations in the industry for clues to correct action (Greve, 1995). Thus, decision makers may evaluate the benefits of adopting new technology by accessing external expertise through social networks, as well as by relying on internal expertise.

The structural holes perspective (Burt, 1992) suggests that organizations that act as brokers, connecting otherwise disconnected firms, receive the best and fastest information from social networks. These broker organizations gain access to non-redundant sources of information, and are able to control the flow of information across networks. Brokers are among the first to learn of new technological adoptions anywhere in the network, and are able to call upon a diverse set of contacts in determining whether themselves to adopt.

In order to play the role of broker between two organizations that themselves have no direct link, the focal organization must have an organizational member who is connected to both
external parties and is well-trusted by both parties. In the current research, we use networks of friendship, advice, and communication to represent the strong ties across which valuable information is likely to travel. Based on the above discussion we predict that organizations playing brokerage roles will have more access to superior information in the external environment, will scan it more actively, and will be quicker to adopt potentially useful new technology.

**Hypothesis 3:** The more the small medical practice acts as a broker connecting otherwise disconnected organizations, the quicker it will adopt useful new technology.

The importance of network position for organizations is likely to differ depending on the age of the organization. Medical practices staffed by relatively newly-trained physicians are less resistant to change and have less recourse to information provided by the network than medical practices staffed by physicians whose training derives from a different era of medicine. For those medical practices run by physicians with relatively out-of-date training, network position might be a more crucial advantage because they are more reluctant to change and more dependent on trustworthy and timely information from disparate parts of the network.

**Hypothesis 4:** The effects of network brokerage on speed of adoption of new technology will be greater for medical practices run by physicians with older training than for medical practices run by physicians with newer training.

**METHODS**

**Medical Innovation Data**

This research focuses on small medical practices faced with the possibility of adopting the prescription drug tetracycline, a promising new antibiotic. The adoption data were collected
from November 1953 to February 1955. Tetracycline was a new compound during this period, as well as a new brand, but it was recognized as belonging to an established family of drugs (Coleman, Katz & Menzel, 1966: 17). The adoption decision, therefore, can be characterized as involving moderate but not extreme uncertainty.

The medical innovation data have been extensively described elsewhere (Coleman, Katz, & Menzel, 1966) and the original data set has been made available for public use (Burt, 1986). We limit our discussion to the specific applications used in this paper.

**Unit of analysis.** In the present study, we created an indicator of whether or not each practice was of the multiple physician variety. The first step in this process was to flag the 63 physicians that reported that they shared an office with another physician. To avoid double-counting practices that had multiple physicians in the data set, and to be consistent with the practice as the level of analysis, we then combined physicians that we believed to be in the same practice. The decision rule for combining physicians into one practice was as follows: to be combined, two physicians had to (a) practice in the same town; (b) mention each other’s name in one of the three social networks (friendship, advice, and discussion); and (c) had to have identical values in at least two of the following four survey questions - proportion of patients over 45, proportion of patients with a certain annual family income (i.e., less than $5,000, between $3,000 and $5,000, or less than $3,000), hospital affiliation, and medical specialty (e.g., general practitioner, internist, pediatrician). This process brought the sample from 125 physicians to 107 practices. Physicians who reported sharing an office but did not appear to match up with another physician in the data set (n = 30) were assumed to share a practice with one of the 91 physicians practicing in these communities who were outside of the adoption data
set (see Coleman, Katz, & Menzel, 1966: 17). These 30 physicians retained the multiple physician practice coding.

The unit of analysis for all variables, therefore, was the medical practice staffed by one or more physicians. For the network variables (brokerage and structural equivalence), for example, the network ties of physicians were attributed to the medical practices with which they were associated. If physicians Smith and Jones belonged to medical practice A, but Smith had a network tie to medical practice B whereas Jones had a tie to medical practice C, then Actor A would be recorded as having ties with both B and C.

Measures

**Dependent Variable: Adoption of new technology.** Actual adoption was coded as ‘1’ if the practice adopted tetracycline during the data collection window and was coded as ‘0’ otherwise. Information on time until adoption was also coded given that we conducted survival analysis rather than regression. The dependent variable in survival analysis incorporates information on time until the event. Hence, we used the information from the local pharmacies’ prescription files that were audited for three successive working days at approximately monthly intervals for the 16 month period following the release of tetracycline for general sale. Thus, the coding, which is summarized in the appendix and ranges from 1 to 17, represents the number of 28½ day cycles until a practice’s initial prescribing of tetracycline (Coleman et al., 1966: 193-194).

**Independent variable: Organizational age.** The aspect of organizational age most relevant to this research was the recency of training of physicians staffing the medical practice. We assumed that the medical practices of doctors who graduated from medical school more
recently tended to be more up-to-date in terms of diagnostic and treatment routines than the medical practices of less recent graduates. The original data set provided a six-level variable indicating approximate year of graduation from medical school, with higher numbers indicating more recent training (see appendix). For the sake of interpretability, we subtracted the training recency value from seven for our analyses so that higher numbers translated to greater age (note that adding or subtracting a constant does not change effect sizes). For multiple physician practices, we used the physicians’ mean level of training recency (cf. Meyer & Goes, 1988).

**Independent variable: Absorptive capacity.** Cohen and Levinthal (1990: 128) argued that the organization's internal ability to evaluate and utilize new technology was largely a function of the level of prior related knowledge, including knowledge of the most recent scientific and technological developments in a given field. According to previous research (Dewar & Dutton, 1986), the number of technical specialists in an organization can serve as a measure of the organization’s depth of current knowledge resources. Thus, organizations with higher numbers of technical experts may have higher absorptive capacity. In this particular data set, medical practices tended to be either solo practices (n = 62) or two-person practices (n = 44) with only one 3-person practice. Therefore, we dichotomized the absorptive capacity variable with 1 = solo practice and 2 = multiple physician practice.

**Independent variable: Brokerage.** This was measured as the betweenness centrality of each actor in the social network (cf. Hoang, 1997). Betweenness centrality refers to the extent to which a focal actor falls between pairs of other actors on the shortest path connecting them (Freeman, 1979). A high betweenness score indicates that the actor occupies a brokerage
position on the shortest path between many pairs of actors, whereas a low betweenness score indicates that the actor offers few brokerage services to pairs of actors seeking to connect.

To obtain the data on the social and professional relations of physicians, each physician interviewed was asked to list the names of three physicians for each of three sociometric questions: (1) "When you need information or advice about questions of therapy where do you usually turn?"; (2) "Who are the three physicians with whom you most often find yourself discussing cases or therapy in the course of an ordinary week -- last week for instance?"; and (3) "Would you tell me the first names of your three friends whom you see most often socially?"

These three questions resulted in network data concerning advice, discussion and friendship respectively. For multiple physician practices, we added together the different network ties of the individual physicians to represent the network ties of the medical practice. As Simmel (1950) has argued, small groups such as dyads tend to form interdependent units. We assumed that the network resources of individuals sharing a practice benefited the practice as a whole.

For each of the four cities in the sample, three network matrices (friendship, advice, and discussion) were merged and pooled to form a single data set that showed the complete set of relationships between medical practices in that city. These four matrices (size 56 x 56, 21 x 21, 18 x 18, and 13 x 13) were analyzed using the network analysis package UCINET (Borgatti, Everett, & Freeman, 1992) to calculate brokerage and structural equivalence.

**Control variable: Structural equivalence.** Structurally equivalent actors are those with similar or identical relations to all other actors in a social network (Lorrain & White, 1971). Previous research has suggested that organizations that are structurally equivalent tend to have
similar patterns of behaviors (Galaskiewicz & Burt, 1991). Thus, we controlled for this possible structural equivalence effect in our analysis.

We used Euclidean distance as a measure of structural equivalence (Burt, 1987: 1330; Kilduff, 1990; Knoke & Kuklinski, 1982: 61). A pair of actors with similar ties to other actors in the network has a small Euclidean distance, whereas a pair with very different patterns of ties has a large Euclidean distance (Scott, 1991: 152). According to the structural equivalence logic, the focal actor is likely to be influenced to adopt by the adoption behavior of the actor with the most similar pattern of ties (Burt, 1987). Therefore, we calculated the date on which each actor's network contacts adopted, and represented the pressure of structural equivalence with the adoption date of the network contact with the smallest Euclidean distance from the focal actor. For some network contacts, adoption information was missing. In these cases, we used the adoption date of the contact with the smallest Euclidean distance for which adoption information was available.

Therefore, consistent with the original research (Coleman et al., 1966) and with recent emphases on the importance of friendship networks for decision making (e.g., Kilduff, 1990; 1992), we included information on friendship relations in all tests of network effects. In dealing with missing data, we preferred the conservative strategy of restricting ourselves to the data available. For those cases where information concerning adoption was missing on ego’s closest structurally equivalent alter, we used information on the closest equivalent alter for whom adoption information was present.

ANALYSIS
Data on time until organizational adoption of tetracycline were treated as survival time data, also known as event history or failure time data (Kalbfleisch & Prentice, 1980). Survival analysis predicts adoption likelihood conditional upon time (i.e., adoption probability at any point in time given that a practice had not previously adopted tetracycline). This approach, relative to OLS and logistic regression, can provide advantages with regard to accounting for both censored data (e.g., nonadopters) and time until the event (Morita, Lee, & Mowday, 1993). To examine the influence of the independent variables on the adoption probabilities, we estimated a proportional hazards rate model (Cox, 1972). This model, frequently used in recent organizational research (e.g., Judge & Watanabe, 1995; Morita, et al., 1993; Sheridan, 1992; Trevor, Gerhart, & Boudreau, 1997), is partially parametric in that it does not impose any distributional assumptions on the data. However, it does assume that hazard functions (i.e., the probability of adoption, conditional on time) at different levels of an independent variable are proportional to some unknown baseline hazard function. Consequently, we examined the graphs of the natural logarithms of the cumulative baseline hazard functions for each level of each predictor (a median split was used for the three interval variables) to conduct Andersen’s (1982) check of the proportionality assumption. For each variable, the functions appeared to be approximately proportional to each other, indicating that the proportionality assumption was not violated for the hazards model.

The proportional hazards regression model, prior to adding interactions, was:

$$h(t; x) = h(t) \exp[B_1(x_{\text{struct. eq.}}) + B_2(x_{\text{training recency}}) + B_3(x_{\text{absorptive capacity}}) + B_4(x_{\text{brokerage}})],$$

where:

$$\hat{h}(t; x) =$$ the hazard function (i.e., conditional adoption probability) at time $t$, with predictors $x$. 

\( h(t) \) = the baseline hazard function,

\( B's \) = the estimated regression weights,

\( X's \) = the explanatory variables.

**RESULTS**

Table 1 shows that the average medical practice in this sample adopted tetracycline about 8 months after it became available. 42% of the medical practices appeared to be staffed by multiple physicians and the medical training (i.e., medical school graduation) of the doctor or doctors on staff tended to have occurred approximately 15 to 20 years prior to the data collection.

The correlation analysis in Table 1 indicates that the three independent variables of most interest (recency of training, absorptive capacity, and brokerage) were all significantly correlated with adoption date, indicating that high levels of each corresponded to quicker adoption of tetracycline. To examine whether the significant correlations remained significant when other variables were controlled for, we took a hierarchical regression approach to the proportional hazards analysis.

The results in Table 2 confirm the overall pattern revealed by the correlation analysis. As suggested by the correlations, a baseline model (not shown) for predicting adoption that only
contained structural equivalence was not significant, as the timing of adoption decisions was apparently not influenced by when organizations with structurally similar positions in the social network adopted. By contrast, Models 1, 2, and 3 indicate that, when added separately to the baseline model, each of the three independent variables of interest had a significant effect on adoption probability. A more robust test, of course, was to simultaneously enter all of the independent variables in the proportional hazards regression equation, as in Model 4. As predicted in hypothesis 1, the more recent the professional training received by the medical practice’s physicians (i.e., the lower the organizational age), the more quickly the medical practice began to prescribe the new drug (p < .01). Hypothesis 2 was also supported, as medical practices staffed by more than one physician (and, thus, presumably, with greater absorptive capacity) tended to adopt tetracycline more quickly than the single physician practices (p < .01). Additionally, Model 4 in Table 2 supports hypothesis 3 in that the more an organization occupied a brokerage position in the social network, connecting otherwise unconnected organizations, the quicker the organization adopted the new drug (p < .01).

The main effects hypotheses for brokerage and organizational age, however, are somewhat subordinate to the proposed moderated effect between the two. The significant coefficient on the interaction term in Model 5 indicates that, consistent with hypothesis 4, the positive effect of occupying a brokerage position on adoption probability was greater for older organizations (p < .05). We also note that absorptive capacity retained its significant positive effect on adoption likelihood in this model (p < .05).

Analysis of effect sizes suggests that the relationships were of practical significance as well. In proportional hazards models, the change in adoption probability, conditional on time, is
equal to one subtracted from the exponentiated product of the coefficient and the size of the change in the predictor. For example, given the .353 coefficient, the effect of being a multiple physician practice (i.e., high absorptive capacity) translated to a 42% increase in adoption probability at any specific point in time. With regard to the interaction effect, effect sizes varied considerably by organizational age. For younger organizations, a one standard deviation increase in brokerage resulted in only a 1% increase in adoption probability. In contrast, for older organizations, such an increase in brokerage translated to a 38% increase in adoption probability. This effect is depicted in Figure 1.

DISCUSSION

The results show consistent support for the hypotheses. The decision on when to adopt a promising new medical technology was influenced by both internal organizational characteristics and the external placement of the small medical practice in the local medical community. The internal factors consisted of how up-to-date the organization was in terms of professional training, and the extent to which the organization could rapidly absorb information from the environment (as measured by the number of skilled professionals available to the organization). The external factor was the extent to which the organization functioned as a broker in its local industry group, connecting otherwise disconnected organizations, and thus being able to harvest new information from disparate parts of the network.
The present research integrates elements from the three main streams of research on organizational adoption of innovation and contributes to a fuller understanding of what is entailed in creating a learning organization. The capacity to recognize and quickly adopt promising new technology depends not only on ensuring that key personnel receive up-to-date training and continuing access to new scientific developments, but also on the social networking skills of key decision makers. Particularly striking was the interaction between internal and external factors. Organizations whose key personnel had less up-to-date training were more affected by their structural position in the industry network. This suggests that organizations can partially offset the inertia that comes with age by establishing strategic positions in the informal network of contacts that spans across organizations. Further research should continue to examine the dynamic nature of the relationship between the organization's internal expertise and its position in the industry network. Do companies gain brokerage advantage partly as a result of reputations for in-house technological prowess?

This research also contributes to the growing interest in the importance of social capital as a distinctive competitive resource (Belliveau, O'Reilly, & Wade, 1996; Burt, 1997). Each organization is embedded in webs of social relations that define access to tangible and intangible industry resources. Further research should examine the extent to which information, advice, help, and other benefits flow along the paths defined by the interorganizational contacts of the key decision makers.

A further contribution of our study is to focus attention on the organizational importance of a celebrated data set, a data set that has hitherto been examined only in terms of individual physicians rather than in terms of the small medical practices to which these physicians belonged.
Further, we have also sought to place the data in an historical context that strongly suggests the importance of relationships of cooperation between physician-organizations rather than competition. In a climate of rapidly changing technology, when consumer demand is unprecedented and growing, small organizations in the same local industry are likely to see each other as resources rather than as cutthroat rivals.

We also focused on the strong bonds of professional identity that are likely to permeate highly regulated and socialized fields such as medicine. As institutionalists have reminded us, organizations in such industries are likely to be receptacles for institutionalized practices that homogenize work and reinforce cross-organizational solidarity (DiMaggio & Powell, 1983).

A possible weakness of using the medical innovation data is that the focus is necessarily on the adoption of an innovation that ultimately proved highly beneficial. Given our preliminary results, further research could examine the effects of recency of training, absorptive capacity, and brokerage on organizational success in avoiding problematic technology as well as adopting beneficial technology.

Another potential weakness of this data is its relative age: Conditions in the medical industry have surely changed drastically since the 1950s. Yet in many ways, the issues facing private medical practices forty years ago parallel concerns that are current today. In the 1950s, physicians worried over twin threats to their autonomy from a) bureaucratized medical empires reaching out from urban areas; and, b) recurrent government attempts to impose some form of universal medical coverage. Today, the threat of takeovers by university dominated medical centers continues, as is evidenced by the controversy surrounding the recent merger of the Penn State Hershey medical center and the Geisinger Health Maintenance Organization (or HMO).
This combined medical empire threatens to dominate health care throughout central Pennsylvania. More ominous, from the point of view of private medical practices, is, of course, the growing power of HMOs of all kinds. Further, as was the case in the 1950s, the AMA has succeeded, for the time being, in beating back federal government efforts to impose universal health coverage. Thus, despite tremendous advances in health care, we find that the challenges facing medical practices remain surprisingly constant across decades in terms of threats to autonomy from both large health care systems and federal government bureaucracy.

Another parallel between the situation in the 1950s and in the 1990s is the rapid pace of change in medical technologies. Medical practices then, as now, faced a “deluge of material” much of which was “highly specialized” concerning new medical advances (Coleman et al, 1966: 14). The establishment of the National Science Foundation in May of 1950 and hugely increased government funding for medical research resulted in a flood of new therapies available to physicians. For example, in 1955 the success of a vaccine to combat polio was announced, an event of tremendous importance given that polio was a leading cause of child mortality and disability (Starr, 1982: 346-347). In this climate of increased technological innovation, medical practices were increasingly dependent on outside colleagues for advice concerning treatment options. As our results confirm, organizations that occupied strategic positions as brokers in the transmission of information tended to be among the first to adopt promising new technologies.

Our research, then, suggests the importance of recognizing the interdependent nature of medical practice. Organizations in the medical industry, according to our analysis, may worry less about what their rivals are doing, and focus more on maintaining contacts with diverse members of the industry. Instead of striving to keep one step ahead of their local competition,
decision-makers may tend to forge bonds of trust and cooperation across the network. By connecting otherwise disconnected groups, decision makers can offer a valuable service to network members, keep abreast of the latest technological advances, and enhance their own social capital.

As Burt (1992) has pointed out, the maintenance of diverse network ties can involve no more time or resources than the maintenance of ties to members of a clique. Given limited resources, the strategy of maximizing diversity of ties is likely to pay greater dividends for the organization than a strategy of shunning contact with possible competitors. Each employee of an organization can be understood as a node in an extended web of contacts that flows across organizational boundaries. Successful learning organizations, we suggest, may seek to enhance and maintain the industry contacts of employees, contacts that may provide timely and significant information.

In conclusion, our picture of a learning organization emphasizes the importance of both internal expertise and external scanning. To keep up with the rush of new technology, the organization needs to develop internally the ability to evaluate new developments, but should not neglect the network benefits of a brokerage position in the relevant industry. Striking this balance between internal and external capabilities is a major management challenge.
REFERENCES


Science Quarterly, 40, pp. 444-473.


American Sociological Review, 49, pp. 149-164.

activity in the biotechnology industry’. Best paper proceedings of Academy of 
Management, Boston, MA, pp. 267-271.


Wiley and Sons, New York.

approach to organizational choice’. Organizational Behavior and Human Decision 
Making, 47, pp. 270-288.

moderators of social influences on organizational choice’. Journal of Personality and 

individual, organizational, and contextual factors on hospital adoption of 
technological and administrative innovation’. Academy of Management Journal, 
24, pp. 689-713.


Weick, K. E. (1979). *The social psychology of organizing*, 2nd ed. Addison-Wesley, Reading, MA.

### TABLE 1

Means, Standard Deviations, and Correlations among Variables (n = 107)

<table>
<thead>
<tr>
<th></th>
<th>Means</th>
<th>s.d</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption date</td>
<td>7.92</td>
<td>5.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adoption</td>
<td>.86</td>
<td>.35</td>
<td>-.72*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organizational age</td>
<td>3.34</td>
<td>1.47</td>
<td>.28**</td>
<td>-.33**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorptive capacity</td>
<td>.42</td>
<td>.50</td>
<td>-.23*</td>
<td></td>
<td>.16</td>
<td>-.13</td>
<td></td>
</tr>
<tr>
<td>Brokerage</td>
<td>2.01</td>
<td>2.57</td>
<td>-.27**</td>
<td>.12</td>
<td>-.10</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>Structural equivalence</td>
<td>9.29</td>
<td>6.03</td>
<td>.02</td>
<td>.00</td>
<td>.04</td>
<td>.04</td>
<td>.22*</td>
</tr>
</tbody>
</table>

* p <.05  
** p <.01
### TABLE 2
Summary of Proportional Hazard Regression Analyses Predicting Adoption (n = 107)

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-.195**</td>
<td>-.170*</td>
<td>-.281**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.070)</td>
<td>(.070)</td>
<td>(.096)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorptive capacity</td>
<td>.491**</td>
<td>.396*</td>
<td>.353 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.211)</td>
<td>(.213)</td>
<td>(.215)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brokerage</td>
<td>.104**</td>
<td>.086*</td>
<td>-.128</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.037)</td>
<td>(.039)</td>
<td>(.126)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural equivalence</td>
<td>-.004</td>
<td>.000</td>
<td>.000</td>
<td>-.014</td>
<td>-.016</td>
</tr>
<tr>
<td></td>
<td>(.017)</td>
<td>(.017)</td>
<td>(.017)</td>
<td>(.018)</td>
<td>(.018)</td>
</tr>
<tr>
<td>Age x Brokerage</td>
<td></td>
<td>.072*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.040)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in chi-square</td>
<td>8.09</td>
<td>5.30*</td>
<td>6.53*</td>
<td>16.54**</td>
<td>3.22†</td>
</tr>
<tr>
<td>Change in df</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Note. Model fit for Models 1, 2, and 3 are evaluated relative to a baseline model with structural equivalence as the predictor. Model 4 is evaluated relative to Model 3. Table contains unstandardized regression coefficients with standard errors in parentheses. One-tailed tests were used for hypothesized relationships.

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

Measures of Variables and Questionnaire Items

1. Adoption Date
Codes are sampling period in which the first tetracycline prescription for respondent was observed.

1. November, 1953
2. December, 1953
4. February, 1954
5. March, 1954
6. April, 1954
7. May, 1954
8. June, 1954
10. August, 1954
11. September, 1954
12. October, 1954
17. February 1955
18. no prescriptions found (nonadopters)

2. Recency of training: How recent was the physician’s medical training?
"In what year did you graduate?"

1. 1919 or before
2. 1920-1929
3. 1930-1934
4. 1935-1939
5. 1940-1944
6. 1945 or later
7. no answer

3. Absorptive capacity: Single or multiple medical practices

(1) Physical proximity to other physicians
“Are there other physicians in this building? [if yes] Other physicians in same office or with same waiting room?

1. None in building/ Some in building, but none share his office or waiting room
2. Some in building sharing his office or waiting room
(2) Young patients
“Could you estimate the proportion of all your patients who are over 45?”

1. More than 33%
2. Less than 33%
3. Missing; no answer, don’t know

(3) Nonpoverty patients
“What proportion of your patients, would you say, have an annual family income of more than $5,000, between $3,000 and $ 5,000, less than $ 3,000?”

1. More than 33% earn less than $3,000
2. Less than 33% earn less than $ 3,000
3. Missing; no answer, don’t know

(4) Home base hospital affiliation
“Are you affiliated with any hospital or clinic? [if yes] Which of these hospitals do you regard as your home base?”

1. Methodist, Peoria
2. Proctor, Peoria
3. St. Francis, Peoria
4. Brokaw, Bloomington
5. Mennonite, Bloomington
6. St. Joseph’s, Bloomington
7. Blessing, Quincy
8. St. Mary’s, Quincy
9. Cottage, Galesburg
10. St. Mary’s, Galesburg
11. More than one or refused to choose
12. No hospital affiliation

(5) Speciality
“Do you specialize in any particular field of medicine?”

1. General practitioner
2. Internist
3. Pediatrician
4. Other specialty
FIGURE 1
Adoption Probability as a Function of Organizational Age and Network Brokerage

- Low Organizational Age
- High Organizational Age