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TECHNOLOGICAL NETWORKING AND INNOVATION IMPLEMENTATION*

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This paper presents a theory of innovation which presumes that new technologies emerge from a firm's accumulated stock of skills. Among these we distinguish technological and networking skills. We examine two aspects of innovating firms: their inclination to adopt a technological innovation, and their propensity to implement innovation alone or with other firms. Historical conditions pertaining to organizational skills are examined to account for these aspects. Among the most important are a firm's cumulative stream of technological projects that have some affinity to the new technology. A second important antecedent can be inferred from a firm's history of technological networking. Networking includes licensing, joint ventures and long-term contracts and can be formed for technological reasons, or for reasons having to do with the delivery of products and services. Networking is deemed important for facilitating access to strands of technology that are alien to a firm. Linkages are also conducive for contemplating strategic partnerships through which a firm can share the risks of innovation with others and which make such partnerships comparatively easy. The study examined a sample of United States commercial banks during the period 1977–1987, some of which were engaged in a new technology: home banking. The findings indicate that technological networking is the best predictor of technological innovation. They reveal also that firms with extensive networking are more likely to implement the innovation with strategic partners. Finally, the paper discusses the implications of the findings for organization design and proposes an expanded theoretical framework for organizational innovation. (INNOVATION; NETWORKING; NEW TECHNOLOGY; STRATEGIC ALLIANCES)

Background

Innovation in organizations follows from the skills or competencies which organizations have accumulated over the course of their history. In the theory and research reported here, we start with this key assumption about innovation in organizations. The firm's stock of skills evolves from its past achievements, and, in turn, forms the foundation for a novel set of skills. Treating innovation as a developmental and ongoing phenomenon (Mohr 1982) should advance our understanding about its incidence.

Central to the present study is the assumption that specific skills need to be present for an organization to implement a particular innovation. Although constrained, an organization can thus leverage its accumulated know-how to try out new ideas. The more a firm accumulates technological know-how, the better will be its capacity to innovate in the vicinity of that know-how.

However, the stock of skills that can be leveraged by the firm to pursue innovations does not have an exclusive internal provenance. These skills might be complemented by extramural sources of know-how, leveraging the home grown skills all the more. This claim is particularly valid when innovations incorporate multiple technologies such as organic chemistry and molecular biology, or telecommunications and computers. The absorption of external know-how is facilitated by the firm's own innovative efforts. For example, a pharmaceutical firm (with skills anchored in organic chemistry) will have a better understanding of new developments in biotechnology if it

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itself has engaged in such R & D. In addition, networking with firms in other industries enhances access to their technological know-how. External partners can provide complementary technology and may participate in strategic alliances to implement innovations spanning multiple technologies. Networking, like technological skills, is subject to learning; a firm's experience in dealing with external partners is therefore an integral component of its stock of skills. Networking requires us to examine the role of firm skills and innovation more carefully.

Organizations often face the vexing choice of implementing innovation internally or through some external form. For example, some computer, banking and biotechnology firms have resorted to internal corporate ventures, while others have been prolific in forming all kinds of strategic alliances. There is a profound tension between these alternatives. A firm might be reluctant to relinquish control over innovative activities that are central to the maintenance of its competitive edge (Burgelman 1983). External implementation raises the danger of appropriability (Teece 1985), and provokes issues of ownership, governance structure and equity in the sharing of costs and benefits among the participating partners. In fact, internal implementation has been the rule and forms the basis of virtually all innovation research and theory. The choice between internal versus external form acquires additional significance when juxtaposed against the history of (inter)organizational skill building.

Some firms have a tradition of solitary implementation and continue to preserve their exclusive control over current activities. Yet, when faced with new developments that require the integration of remote but indispensable strands of technology, a solitary firm may be hampered in its innovative efforts. Their competitors, with a history of networking, have a greater capacity to combine their proprietary technology with that of others. These latter firms might also have a greater propensity to innovate externally, since they are more familiar with forming strategic partnerships. These very considerations are central to the present study.

Objectives

The paper presents a theory on firm specific skills and innovation. Two problems are examined. First, we make an attempt to explain the incidence of a specific type of innovation due to the accumulation of firm specific skills. Second, we try to explain why firms innovate through some form of strategic alliance, while others choose to do so alone. We examine the firm's past, broken down into its **technological experiences** and **interfirm networking**, since we believe that their documentation informs us about competencies that explain a firm's propensity to innovate. A tally of these time-dependent competencies facilitates the explanation of innovation. They are also examined to account for the implementation of innovation in the form of internal corporate venture or strategic alliance. This approach required us to abandon a cross-sectional research tradition which is so common in innovation research. A longitudinal sample of organizations was obtained to examine how cumulative technological skills and interfirm networking account for the rate and organizational form of implementation. The dependent variable takes, therefore, two forms: adoption of a new technology, and choice of structural arrangement (internal versus external) to implement the adoption.

The research setting involves a sample of U.S. commercial banks, some of which have made attempts to introduce home banking. Home banking is a new technology. Its realization requires both banking and nonbanking skills and could therefore be labeled as "hybrid" innovation. Several technologies are being combined here, particularly telecommunication and computers with financial service delivery. Home banking is also a service that often is delivered through an interfirm network, inducing banks to seek out partners to implement the innovation. Recently, the

banking sector has shown an extensive amount of strategic partnering and provides, therefore, an ideal setting for testing a history-based theory of the implementation of an innovation, i.e., whether banks act alone or in collaboration with others. Joint ventures and internal corporate ventures proliferate as structural innovations in many industries, and documenting their occurrence in the financial services sector should therefore have a wider significance.

Elements of a Theory

We propose a dynamic theory of innovation incorporating know-how from various sectors. The implementor is either a single organization or a partnership of organizations. Because many firms are specialized, we assume that innovators among them are often inclined to pool their technological skills through strategic alliances, establishing the imperative that they innovate both technologically and structurally.

There are several theories in the literature that we seek to integrate more formally. We have made an attempt to refashion various ideas of Nelson and Winter (1982) on innovation emanating from *skills accumulated by the firm*. These authors are followers of Schumpeter (1934), and provide a strong argument for innovations being developmental or *evolutionary*, in that new ideas amount to nothing more than a recombination of existing skills. We stress the importance of *history* and suggest a dynamic theory of innovation. Unfortunately, there is an over-emphasis on the single firm (or entrepreneur) as the creator or implementor of innovation. We are struck by the amount of *interfirm networking* that goes on (e.g., Evan 1966) coupled with several trends in *converging technologies* as documented by Scherer (1982) and Astley (1985).

Organizations as Skills

We start from the assumption that organizations have accumulated an extensive range of skills, which give them a competitive advantage over others. Innovations evolve from these skills, so while innovation is a new addition, it is at the same time an outgrowth of previously acquired know-how. If the new addition is too remote from the current skills, we would expect the innovation not to materialize, or at least not have a high success probability.

Innovation is therefore viewed by many as being incremental. Among the best known proponents of such an incremental view are Nelson and Winter (1982). They hold that organizations are repositories of routines. These routines play a large role in implementing innovations. In fact, innovations are not radically different from previously followed routines, but are more often novel combinations of existing routines. The old routines are necessary elements of innovations, whether they are technological or structural (compare, however, Normann 1971; Tushman and Anderson 1986).

Technological Convergence and Innovation

The importance of extramural know-how seems particularly salient in sectors where innovations are grounded in the simultaneous development of interrelated strains of technology. These strains originate from different scientific fields. Such innovations require a confluence of technologies, a confluence brought about by several firms whose production and marketing interests are not organizationally related (Phillips 1985).

At the industry level of analysis, important research by Scherer (1982) has shown that some industries are major suppliers of innovative output for other industries. Scherer's (1982) study consisted of an input-output analysis involving R & D flows

among numerous industries and provides an interesting display of "converging technologies." Convergence or confluence is inferred from the level and growth in R & D flows between two or more sectors or industries. It is reasonable to assume that such flows can be interpreted as some form of technological confluence. Firms in industries which are buyers of R & D output originating elsewhere must have the capacity to integrate that output into their own domain. Semiconductor technology has been the most widely disseminated technology, particularly towards the telecommunication and financial services sectors. Astley (1985) has given further depth to the Scherer findings, and showed that the computer and telecommunication industries become increasingly blended.

Networking and Technology

Networking can be coupled with technological experiences which the firm accumulates in the course of its history. The proprietary technology is not only a major requirement for contemplating certain innovations. When combined with extramural technologies, the firm's homegrown skills are also crucial to absorb those technologies (Cohen and Levinthal 1989). Interfirm skills are therefore crucial on two accounts: they facilitate access to external know-how, and they confer a greater competency to create new interfirm structures, such as joint ventures. In sectors with converging technologies, firms which have aggressively networked themselves have a major advantage over firms which traditionally have followed a more solitary path toward innovations. With a twist, we might argue that the former are "cosmopolitan" rather than "local" (Gouldner 1957).

Cooperative arrangements facilitate transfer, but they themselves require the innovative allotment of resources and outcomes with other organizations, together with the formation of precarious governance structures. Given the widespread experimentation with internal "entrepreneurship," there are many organizations which follow a solitary route to new technology rather than to externalize their innovative efforts. Whatever an organization's skills in building internal or joint ventures, some of these skills are as critical for successful implementation as are available technological skills.

The joint consideration of technological and structural skills is a major element of the present framework. Technological feasibility of innovations is not sufficient for the implementation to materialize; they are also dependent on the availability of certain infrastructures to harbor the new technology. In the absence of structural skills, new technology remains "near technology" rather than technology "in use" (de Solla Price 1980). Near technology refers to skills which the firm is aware of, but has not yet put into practice. A firm will innovate when its market is seen as providing a reasonable probability of obtaining returns that are commensurate with the risks and costs. The convergence of multiple strains of technology might offer many possible innovations, but the number that is actually implemented will be limited. They are limited to firms whose skills confer access to internal or external forms, and which allow them to capture the innovation's economic rewards (Phillips 1985).

Banking

The U.S. commercial banking sector presents an attractive setting for researching organizational innovations. Although a service sector, rather than a manufacturing sector, banking provides a prototype of alien technologies becoming merged with its own. Its firms show sharp variations in technological innovation. Networking among banks, as well as between banks and providers of information technology, is widespread.

Banking Technology and Information Technology

That banks have been at the crossroads of converging technology is clearly indicated by the earlier mentioned study of Scherer (1982), who examined R & D flows among a number of U.S. industries. Scherer discovered that banking is the most extensive buyer of information technology, far exceeding other sectors such as capital goods manufacturers or transportation. The financial services sector acquired almost 66% of the information technology sector's total revenue during the years 1970–1980 (Compaine 1984).

Information technology has permitted a flood of innovations that banks need to be part of. Credit cards, magnetic coding, smart cards, points of sale, bank by phone, automated teller machines, electronic fund transfer, corporate treasury stations and home banking have refashioned the banks' service delivery systems and reshaped the competitive nature of their industry. The banking innovations in the U.S. date from the Civil War, beginning with checkable deposits. These innovations are not purely technical. Rather, they brought about formidable organizational innovations. While technical innovations were comparatively simple, their widespread diffusion among all banks was essential for them to yield efficiency improvements. For example, the bank card requires many clients, many vendors of goods and services, and last but not least, many peer institutions to implement the "simple" innovation rendering it an "architectural" innovation (compare Henderson and Clark 1990). The acceptance required a complex interfirm organizational arrangement from clearinghouses to American Banker Association task forces. Interfirm coordination demands are thus profound in a sector like banking when the set of feasible innovations expands.

Financial Networking

Naturally, there are also other classes of firms confronted with converging technologies; we need to mention only pharmaceuticals, airlines, health care providers and telephone companies. The ability to absorb external technology for successful innovations should also be critical in these industries. We suggested so in the introductory paragraphs with the example of pharmaceutical and biotechnology firms whose technologies overlap more and more. Similarly, commercial banks continue to expand on their repertoire of networking skills and fine-tune their interdependent service delivery systems, particularly regional or national automated teller machine (ATM) networks. The diffusion of ATMs within and across banks has shown a phenomenal expansion in the U.S., and led to the creation of networks such as "MAC" and "Cirrus."

Other linkages have been created with suppliers of information technology. For example, BancOne, a Midwestern bank, has created a joint venture with EDS to develop banking software. Other banks have developed partnerships with telecommunication firms and merchandising firms to create so-called "point of sales" systems. The present menu of feasible technological innovations provides additional incentives for interfirm linkages, because their implementation will increase the timeliness, reliability and comprehensiveness of information that is available to transactors. Linkages with information technology firms and with peer commercial banks have been particularly prominent around the creation of a recent innovation, home banking.

Home Banking

Home Banking represents an interesting illustration of an innovation that incorporates multiple strands of technology: financial services, telecommunication and computer technologies. Home banking, or video banking, is a manifestation of a newly

emerging technology called "videotex." We believe that the diffusion of home banking presents an ideal opportunity for examining how a firm's stock of skills combines with its history of technological networking in explaining the propensity to innovate. Since many home banking innovations occur through some form of strategic partnership, the researcher enjoys an additional benefit of exploring why some innovators act singlehandedly, while others prefer to implement the innovation with strategic partners.

Videotex involves the transmission of data from information providers over telephone cables. Home banking is one example; it is a service that allows a client to use a personal computer for interacting with the bank and other information providers, for example, to transfer funds, verify his account, and purchase anything from airline tickets to securities. Users can be linked into a network through a "gateway" with a variety of information sources, including their financial institutions. For banks, the delivery of such services entails an acquisition of sophisticated electronic and telecommunication capabilities which have to be compatible with their internal hardware and software systems. In the absence of such systems, videotex remains a distant illusion (Aumente 1987). Videotex draws telecommunication and computer technologies into the world of banking. Any commercial bank contemplating its realization requires major skills in information technology.

Based on our theoretical framework, it can be surmised that having networked with firms that supply relevant hardware and software affords a significant competitive edge. Home banking is far more complex than personal computers, which serve as off-shore automated teller machines (ATMs). Yet, innovations with ATMs will facilitate home banking because ATM hardware and software experiences generate the stock of skills required for home banking.

Unlike recent banking innovations such as the NOW account (Nord and Tucker 1987), equity lines of credit and certificates of deposit, home banking requires major capital investment, is not readily mimicked and might convert part of the bank into a data processing facility. Because it is at once a product and process innovation, it may not fit the operations department, or "back office" where most process technology resides. According to Scherer (1982), research and development outlays in the financial services sector have been minimal, making it almost inevitable to develop home banking with other firms. Yet, as we have argued, some prior technological experience with information technology is essential, as banks also need "absorptive capacity" (Cohen and Levinthal 1989) when contemplating a new technological innovation. Such experience is indicated by electronic data processing, automated teller machine and other technological activities.

We have also stressed the importance of interfirm networking. Some networking involves peer banks for coordinating interbank service delivery. Other networking is created for technological reasons and it is particularly this form of networking that enhances the propensity to innovate. Significantly, the above mentioned ATMs have created a major opportunity for interfirm networks, and these too will be advantageous for a more successful implementation of home banking. Of course, other moves involving information technology might entail networking. For example, when a bank has a long-term lease with a satellite transmission firm, or R & D agreements with a manufacturer of customer software, we expect it to have easier access to requisite home banking technology. Home banking incorporates multiple strands of technology, some of which are more or less alien to an adopting bank. Networking will diminish the distance that a bank has to travel toward those technology strands. And it improves a bank's ability to overcome the reluctance to form external partnerships such as joint ventures, and to share the costs and benefits of the innovation with strategic partners. In the methods part of this paper, we identify pertinent technologi-

cal experiences and interfirm networking that are deemed germane to the adoption of home banking and the form through which it is implemented.

Summarizing, any commercial bank is capable of adopting video banking. Whether a bank does so hinges on its accumulation of videotex relevant skills and on the magnitude of its prior technological networking. By examining home banking, we compare banks which implement the innovation versus those that do not. Secondly we compare banks which realize home banking singlehandedly, versus those that do so through some form of strategic alliance. Longitudinally, we examine a bank's involvement with home banking in relation to its technological experiences and interfirm networking. These comparisons should inform us not only about who innovates, but also about which (inter) organizational form is chosen for the implementation of innovation.

Hypotheses

From the theoretical considerations, it should be evident that both technological skills and interfirm networking are considered important because they increase the firm's exposure to a comparatively larger and more diverse pool of skills, and together with technological experiences diminish the distance that separates the current firm from its intended innovation. The empirical researcher should explicate the technological experiences, the ingredients of which become refashioned into the new service. In other words, specific technological experiences are pertinent to the content of innovation. This caveat accords very much with Mohr's (1982) view that innovation research requires "middle range" theories and research, customized toward specific innovations and their specific antecedents. For home banking these experiences include computer hardware, software, telecommunication, and information delivery.

Structural experiences, past and present, are also conducive for innovation. Networking increases variety and serendipity. Networks give better access to new developments that reside in significant other organizations, particularly carriers of exogenous technologies. As a nontechnological form of learning, networking also endows the organization with important administrative skills [e.g., recruitment and socialization of new members, liaison roles, and governance] at its boundaries, skills which can be activated in the future.

From these observations we can hypothesize:

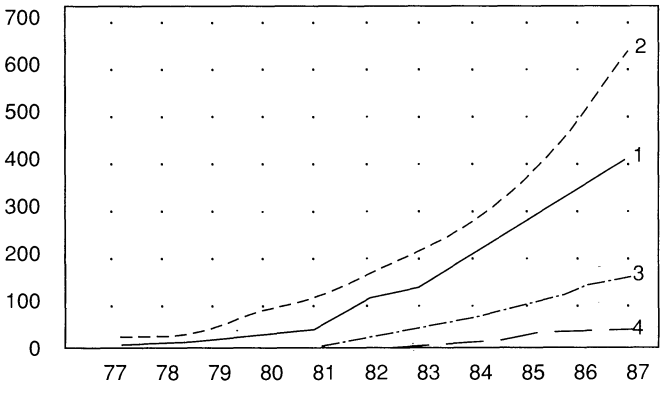
1. The magnitude of a firm's cumulative technological experiences and technological networking affects the probability of innovation.

The discussion of interfirm networking and innovation gives rise to a second hypothesis:

2. Among technological innovators, those with extensive prior networking are more likely to innovate with strategic partners.

In this study these hypotheses will be tested while holding a number of organizational and environmental attributes constant, including several that the innovation literature has identified as important: including organizational size (e.g., Rogers 1983), economic performance (e.g., Nord and Tucker 1987) and number of competitors, demand factors or even "market failures" (e.g, Mansfield 1963; Williamson 1975; and Scherer 1982). These attributes will be viewed as "control variables" since they fall outside the purview of the theory presented here.

A similar statement should be made about an organization's general proclivity to innovate. Authors such as Nord and Tucker (1987) and Bantel and Jackson (1990) have provided interesting insights on innovation in the banking sector. Nord and Tucker examine a nontechnological innovation, while Bantel and Jackson study



Note:

1 ———— Cumulative number of technology-related innovations
2 - - - - - - Cumulative number of non-technological innovations
3 —·—·—·— Cumulative number of technological innovations through interfirm linkages
4 —— —— Cumulative number of non-technological innovations through interfirm linkages

FIGURE 1. Number of Significant Innovative Events and Interfirm Linkages in Commercial Banking Industry, 1977–1987.

organizational **innovativeness**. This study resembles the Nord and Tucker study in that we deal with a specific innovation. Nord and Tucker studied the adoption of the NOW account. Bantel and Jackson checked off a long list of mostly "trivial" innovations, ranging from branch lay-out, financial services, personnel procedures, documents design, and back office operations. The score on such a list might be symptomatic of a bank's proclivity toward innovation. This study does not assess a bank's innovativeness, but recognizes the need to hold such proclivity constant while examining the effect of specific historic antecedents of an innovation.

The Research Setting

In the present case, home banking in the United States during the 1980s is being considered for testing our "mid-range" theory. Home banking is a new service which surfaced in the United States in 1981 and which had been realized by some 65 banks by 1986. For our purposes, it is informative to display the exponential growth in information technology among commercial banks as a backdrop against the emergence of home banking.

Recent developments appear truly astounding. From Predicast (1977–1987), innovative activities and interfirm networking during the past decade were tallied and plotted. Figure 1 presents a graphic display of these activities.[1] The number of innovation events in Figure 1 refers to the aggregate number from 152 of the largest U.S. commercial banks. Nontechnological innovations (e.g., reorganizations, changes in personnel procedures, compensation systems, new financial products, etc.) show a constant increase. Technological innovations (e.g., automated teller machines, check processing automation, software development and sales) rose sharply, especially in the period 1981–1984. What is even more striking is the heavy preponderance of technical linkages (47% average) compared to nontechnological linkages (10% average), many of which were with computer organizations. Interorganizational exchange

[1]See the Method section for a complete description about sample and data collection.

relationships, prior to 1980, which were created for technological purposes, were relatively rare (about 10%). These trends are even more pronounced than those in the earlier mentioned Scherer (1982) study on R&D flows involving the financial services sector and the sectors which can be loosely lumped together as representing information technology, i.e., telecommunications and computers.

Method

This study deals with dichotomous dependent variables and predicts a single-event history variable: whether or not the innovation was implemented internally or externally. From the banks' histories we cut out an eight-year window, i.e., the data were censored. The study is right-censored to the time of data collection, i.e., 1988. Left-censoring is not an issue here, as data were collected from 1977 onward, while the first home banking services were not offered until 1981. Right-censoring can be dealt with successfully by employing the discrete-time event history analysis. Strictly speaking, this means that innovating banks are compared with noninnovating banks on the basis of a number of attributes. Thus, the study has many of the features of a case-control design. Such designs are common in research on lung cancer, toxic shock syndrome and epidemiological investigations on rare outcomes.

Unlike the cohort design, the case-control study traces effects to antecedent conditions (Anderson et al. 1980; Schlesselman 1982). Units with the variable of interest and those without are compared with respect to the hypothesized explanatory variables. In contrast, in the cohort design, the research proceeds from cause to effect. A simple random sample, or a stratified sample of units, is selected and classified according to their exposure to the hypothesized independent variables. The dependent variables are measured and the exposed versus unexposed units are compared on this variable (Schlesselman 1982).

The case-control design is highly appropriate for innovation studies, since adoptions in a particular year are comparatively rare. In a cohort study, a stratified sample of banks would be selected with the strata being based on the hypothesized independent variables. Afterwards, data would be collected on whether or not videotex was present. Obviously, such a design would require a large database to comprise enough events. The case-control design requires fewer organizations. In the present study, it selects banks on the basis of whether or not they had home banking, together with the collecting of relevant independent variables. Innovators are then compared with noninnovators.

The independent variables were time-related. A discrete time method of logit modelling (Allison 1982, 1984) was employed for incorporating the time-varying covariates of the model. This decision appears appropriate as the event is usually located in a particular year, i.e., the date or month of announcement might be known, but not the specific date of implementation.

Research Design

The general model for testing the hypotheses is as follows:

$$\text{Home banking (or form of implementation)} = f\,(\text{pertinent information technology experiences, interfirm networking, industry attributes, organizational variables}).$$

This model follows directly from the theory. It stipulates that the probability that banks implement home banking is contingent upon the earlier described experiences in information technology and prior interfirm networking, while holding constant a host of other variables such as number of competitors, or firm size. All these independent variables are time variant.

Allison (1984) is followed in using a discrete time event history analysis to conduct a logistical regression analysis:

$$\text{Log } P(t)/(1 - P(t)) = a(t) + \Sigma b_i x_i(t).$$

$P(t)$ is the probability that an event (a bank implementing home banking) occurs at time t. The term $a(t)$ implies that the hazard rate for implementation varies across time. Since home banking was first introduced in 1981, a window of seven years (1981–1987) was created. To estimate $a(t)$, a set of six dummy variables was entered into the model. Vector **[b]** contains the regression coefficients of independent variables, indicating their effects on the log-odds of the hazard, where i is the number of independent variables in the model. Estimates of parameter b are obtained from the maximum likelihood method. This method treats the data as quasi-cross-sectional; if a bank gets home banking in year one, it contributes one organization-year, and at year two, two organization-years and so on. Noninnovating organizations contribute as many organizations-years as there are in the window. In short, each of the censored organizations contributes a maximum of n organization-years, where n is the longest time interval.

In the test for the second hypothesis, the dependent variable becomes a combination of two states, home banking and its organizational form of implementation. Because only six of the 49 banks were involved in a joint venture, they were lumped together with banks that implemented the innovation through licensing agreements or long-term contracts.[2] The organizational form gets operationalized into interval versus external.

The Sample

The hypotheses were tested with a set of 152 banks, drawn form a list of approximately 250 banks as reported by the American Banker during the period 1977–1988. This constitutes the population "at risk." Risk refers here to the chance of getting home banking. Initially we made an attempt to construct a 100% sample, but unfortunately many banks had to be deleted because of insufficient data. The elimination proceeded retroactively, where as many banks as possible were collected whose data were complete, with as primary consideration nonmissing information with respect to the dependent variable. In the present study cases were deleted due to a variety of factors. Some were missing because a corporate take-over or leveraged buy-out effectively removed them from the original listing. Others were missing because annual reports from earlier years were no longer available. Additional factors include a change in headquarters location or their private legal status rendered them inaccessible to the researcher. Note that the study called for many variables, over eleven years, and that a gap of two years on one variable would effectively eliminate the entire observation.

Of the initial set of 250 banks, 53 were involved in home banking. Forty-nine of the 152 banks in this study are known to have implemented home banking. Thus, we are

[2]This method can be compared to a multinomial logistical regression with the dependent variable having three levels: nonadoption, internal and external adoption. Currently, computer programs for such an analysis are not available. Its results are very likely to resemble those reported here (Allison, personal communication).

able to secure almost a 100% sample of the innovators which are to be compared with a "control" group of 103 noninnovators. The 152 banks of the study are slightly bigger than the excluded ones. Typically, they are also firms whose records are better accessible, and which still existed in 1988. Appendix A lists the banks that were included in the sample, Appendix B the firms and their form of implementation during the period 1981–1987.

Measurement

There are four sets of independent variables: technological experiences, prior interfirm networking, organizational and industry attributes. The variables and their descriptions are listed in Table 1. All these variables were time-dependent indicators.

Cumulative Technological Experiences. Technological skills were operationalized by two variables, information technology experiences and investment in systems and equipment. The first variable consisted of the cumulative number of times a bank had been involved in information technology projects. These projects are reported in the *Predicast Index* (1977–1988). We call such prior events technological "experiences." Experience has been defined in dictionaries as "something enjoyed, shared or lived through," "personal trial, observation or practice," or "knowledge gained by practice, trial or observation."

The second information technology variable was obtained from a time series of annual reports and is also presumed to signal cumulative skills. Increased investment in systems and equipment reflects "learning by using" (Rosenberg 1982) and permits a firm to produce its output more efficiently. Such investments promote also a firm's absorptive capacity" (Cohen and Levinthal 1989). Learning by using is distinguished from "learning by doing," a term coined by Arrow (1962), and is illustrated by the *Predicast* (1977–1988) derived measures. When developing new technology, say a regional ATM network, a bank is involved in problem solving, trying to come up with new insights, routines and other organizational skills. It learns while making an attempt to put the new technology into practice.

The *Predicast* volumes provide the titles of articles which have appeared in a variety of media. The items therein were treated as information on a particular bank's relevant experiences. Only actual activities, financial commitments and **not** intended or surmised "trials" were included in the counting of prior experiences. Given that the theory calls for pertinent prior technological experiences in relation to videotex, the following classes of technological experiences were ascertained during the period 1977–1987: "Computer Operations," "Automatic Teller Machines," "Bank/Smart Card," "Telecommunication," "Point of Sales."

Interfirm Networking. The *Predicast Index* (1977–1987) was also consulted to measure cumulative interfirm linkages. The number of times a firm formed any type of strategic alliance, either with peer institutions, providers of information technology or with other classes of organizations, was counted. Thus, a bank's interfirm networking events were tallied with respect to "Licensing and Contract Agreement," "Joint Venture," "Purchase System" and "Merger and Acquisition." The links were also specified with respect to type, i.e., "Computer Hardware", "Software House," "Telecommunication," "Others," "Banks," "Financial Services" such as brokerage firms and investment banks, "News/Publishing Firms," "Retail/Merchandising" and "Other Transaction Providers, Hotels, Etc."

Proportion of Technological Exchange Relationships. A separate networking measure, signalling the saliency of technology in interfirm networking was constructed: "proportion of technological exchange relationships". It conveys the technological intensity of interorganizational conduct, and might furnish additional insight on the

innovation likelihood. Some banks have a strong propensity to network, but may not reveal any tendency in the type of linkages (e.g., linkages involving financial products, versus new technology, etc.). The percent of a firm's strategic alliances with an information technology purpose, as a variable, might be particularly informative in a sector where innovations might include contributions from other sectors. Firms with selectively created technological alliance might have a pronounced advantage in the realization of home banking.

Environment and Firm Attributes

Innovativeness. The *Predicast* source was also used to count the frequency of nontechnical innovations to measure what we call "innovativeness." These included "Marketing", "Personnel" and "General" and are illustrated by new financial instruments such as NOW account, sales promotion campaigns, reorganizations, change in executive compensation plans, and the creation or consolidation of divisions. These were presumed to reflect an organization's proclivity towards banking innovation and is used as a control variable.

Examples of *Predicast* entries are:

"Reorganization to form community banking and national consumer sectors" (general/nontechnical innovation);

"To use artificial intelligence for foreign exchange trading" (technological innovation-software);

"To jointly form Fleet/Norstar Financial with Fleet Financial for $1.3bln" (interorganizational-banks);

"National City and Ameritrust introduced on-line telephone enquiry services" (interorganizational-telecommunications).

These entries represent a direct "translation" of pertinent experiences and were counted to arrive at cumulative scores.

The coding scheme to classify the various *Predicast* event categories was developed by trial and error; it reflects the previously mentioned requirement of deducing the pertinent information technology experiences and interfirm networking. Some overlap between these two variables was unavoidable, however. An occurrence of technical projects employing interfirm arrangements (e.g., "Banc One jointly develops with E.D.S. video software") should be coded as both a technological and an interfirm event. The firm's information technology and networking scores represented the cumulative number of involvements up to the year of innovation. In other words, the study used experiences and linkages up to the time that home banking was implemented [except, of course, those of the firms that did not innovate and were not censored until at the end of the time window]. The innovating firm was deleted from the data set in the year of innovation.[3]

The bank's environment was defined in terms of the state where its headquarters were located. Two environmental attributes were measured, using archival material from the Federal Deposit Insurance Corporation for the period of study. They are number of peer banks and size of consumer demand for financial services in the bank's state. Several organizational attributes were extracted from the bank's annual reports and *Moody's Manual for Banking and Finance* (1977–1988), including size, measured in terms of assets and return on equity. Finally, we included a measure of innovativeness. As was already mentioned, inclusion of this variable permits us to examine the specific effect of the variables of interest.

[3]A copy of the coding scheme is available on request from the authors.

TABLE 1
Measurement of the Independent Variables

Variable	Measurement
Technological:	
1. Technological experiences	Cumulative number of projects involving computer operations, ATM, Bank/Smart Card, telecommunication and point of sales, events 1977-to date (Predicast Index)
2. Investment expenditure, systems and equipment	Total $ investment in systems & equipment/company asset—3-year average (Annual Report)
Interorganization:	
3. Interorganizational experiences	Cumulative number of interorganizational actions including licensing/contract ventures, mergers and acquisitions and system purchases, 1977-to date (Predicast Index)
4. Proportion technological, interorganizational links	Cumulative number of technological links/Total number of exchange relationships including licensing/contract agreements, joint ventures, mergers and acquisitions and systems purchases involving computer and telecommunication know-how, 1977-to date (Predicast Index)
Organizational Attributes:	
5. General/Nontechnical	Cumulative number of projects, trials, innovations involving marketing, personnel and general reorganizations, changes, replacements of existing conditions, 1977-to date (Predicast Index)
6. Size	Log $ asset (Annual Report)
7. Return on equity	Net Income/Equity—3-year average (Annual Report)
Environmental Attributes:	
8. Size of demand	Log—$ consumer loan in the state (FDIC)
9. Number of banks in the state	Log—number of banks (FDIC)

The Dependent Variable: Home Banking. The dependent variable is the innovation event and was scored as a zero-one. The unit of analysis being the firm-year, each observation was coded 1 if the organization realized home banking *in that year* and 0 if it did not. Once home banking has been installed, it contributes no more observations to the data pool. The dependent variable for hypothesis 2 was scored in the same way: among innovators it "flags" the form of implementation, i.e., internal versus external. Two dichotomous dependent variables were created, one for internal (1 internal implementation, 0 otherwise) and one for external installation (also 1, for external implementation and 0 otherwise). In other words, the event was determined to entail either internal or external innovation, and not simply innovation. In the analysis we first compared the internal innovators with the rest of the sample, followed by a similar procedure, but now for the external innovators. The event history analysis was performed separately for the two types of events.

The list of home banking firms was obtained from the Arlen Communication Inc. (1985) Videotex Directory, the 1985/1986 Retail Electronic Fund Transfer Directory, and the American Banker surveys (1985–1987). This collection was a trial and error process, working backwards and forwards, checking entries in different publications against one another. In cases of doubt, telephone calls, Predicast listings and annual reports were used to further verify the presence and timing of the realization. In general, if data were incomplete, the bank was deleted from the data set. A bank was not deleted if in an organization's data matrix some part of only one year was missing. In those cases the missing data were calculated through interpolation. Several listings of commercial banks, together with listings of home banking adapters, led to the creation of a file of banks, including most (49 out of 53) that realized the innovation.

Triangulation of Measurement

Three procedures were followed to test the validity and reliability of the data. The two authors scored the technological and interorganizational entries as reported in the *Predicast* index, employing the coding scheme, mentioned in footnote 3. Several trial sessions were held to improve coding decisions and to familiarize the authors with the data source. After having selected three banks randomly, the results of the two coders were compiled. The inter-rater consistency of *Predicast* derived indicators on technological and interorganizational experiences was 0.763 (Pearson; $p < 0.0001$). This calculation was made just after the coding guidelines had been established.

Furthermore, two simple triangulation procedures were followed. A small-scale study reported in *Computerworld* (1986), involving some 100 firms outside the microelectronic sector, yielded a ranking based on the magazine's assessment of their advancement in computerization. The survey included ten financial institutions. Two organizations, one of which was an S&L institution, did not belong to the study's listing and reduced the comparison to eight pairs of innovation scores. The magazine's score could be compared with the total number of technological innovative events of the matched organizations. The rankings from the two sources are presented in Table 2. The Spearman rank order correlation between the *Computerworld* score and the technological experiences score, calculated from the *Predicast Index*, was 0.833 ($p = 0.03$). Although a modest validation procedure, this comparison suggests that the Predicast's derived variables have concurrent validity.

Finally, the authors conducted a set of telephone interviews with 36 senior executives in divisions which are relevant with respect to information technology. Each bank has a unique way of accommodating information technology, and labels of divisions range from "Credit Card" to "Systems." After extensive trial and error, an appropriate informant could be located in some of the banks. Recall that our time window was 1977–1987; as organizations, banks have a rather short-term memory, and it was difficult to inquire beyond a few years about their technological conduct.

The survey inquired about the implementation of a number of information technology-based banking activities, classified into categories of automated teller machines,

TABLE 2

Comparison Between Predicast Score and the Computer Survey Findings

Bank	Total Score Computerworld	Cumulative Technol. Experience	Asset	Weighted Score
BancOne	12,400 (1)	8	18.73	0.427
Bank America	11,275 (3)	34	92.83	0.366
Corestates	11,160 (4)	5	15.04	0.332
Citibank	11,020 (5)	50	203.60	0.246
First Union	10,975 (6)	2	27.63	0.072
First Chicago	10,600 (8)	5	44.21	0.113
Man Hanover	10,350 (9)	17	73.35	0.232
First Wachovia	9,925 (10)	2	19.34	0.103

Note.

(1) Two firms in the Computerworld Survey, Norwest Corp and Home Federal S&L were not in our sample.

(2) Parentheses: the rank of company in the *Computerworld* survey.

(3) Cumulative technological experience: total number of technological innovative events of each firm reported in the Predicast Index, 1977–1987.

(4) Weighted score = (3)/asset.

(5) Spearman rank order between the *Computerworld* score and the weighted score calculated from the Predicast Index = 0.833, significant at $p = 0.03$.

phone banking, point of sales and corporate home banking.[4] In each category, a code of 1 was assigned when the category was present, and 0 otherwise. From the *Predicast Index* comparable scores were created. If the organization was involved in one or more information technology projects during the period 1977–1988, it received a score of 1, and 0 otherwise. There was a reasonably high level of consistency between the survey indicators and the *Predicast* indicators of technological innovation. The *Predicast Index* tends to under-report the event. It should be noted, however, that the *Predicast* measures are left-censored at 1977, the year when most banks had already installed ATMs. On the other hand, the other three classes of information technology events are relatively recent and coincide better with the *Computerworld* window. If ATM events are eliminated from the analysis, the comparison shows 17 errors out of 72 entries, i.e., a hit rate of 76.4%. It was found, however, that the under-reporting was not related to size; if there is a gap between the archival and interview reported activity, such a gap does not appear to coincide with the size of the bank's assets. It can be concluded that the present measurement of technological experiences and interfirm networking amounted to a successful effort at gauging a very elusive behavior. If their use helps to support the hypotheses, one can also infer them to have "construct" validity.

Results

Table 3 presents the number and cumulative rate of home banking during the period 1981–1987. It is evident that the number of cases over this period has an inverted, *U*-shaped distribution which peaks in 1984, the year in which significant deregulations were announced. Strategic alliances are nearly twice as common as internal forms of implementation. Thus, the data display an interesting distribution with respect to both timing and form of implementation. As mentioned before, no claim on representativeness is implied.

Figure 2 shows that the hazard rate increased rapidly prior to 1984 and declined equally rapidly afterwards. This rate is computed by dividing the number of innovations by the number of noncensored observations for that particular year. Figure 2 reveals the hazard rate to be nonmonotonic as indicated by the inverted *U*-shaped curve.

Table 4 shows a considerable variation in the independent variables. Among the networking variables, the standard deviation for both networking and networking for technological purposes is quite large. The same applies, *a fortiori*, for the technological experiences variable. Table 4 contains also the product moment correlations among the independent variables. The matrix shows that a bank's information technological experience is strongly associated with interfirm networking: the correlation between technological experience and networking is 0.77. Technological experience correlates similarly with the proportion of technological exchange relationships ($r = 0.67$). This finding indicates that heavily networked banks tend to gravitate towards strategic alliances having a technological mission. Yet their separate effects need to be explored.

Adoption of Technological Innovation

Table 5 presents the test for the first hypothesis. It shows the results of two models. The first one includes the six dummy variables corresponding to the years in the window 1981–1987, while the second is truncated, by eliminating the dummy variables. The results reveal that networking is conducive to the implementation of home

[4]A copy of the interview schedule is available on request from the authors.

TABLE 3

Means and Standard Deviation and Product Moment Correlations of Independent Variables

Variable	Means	S.D.	1	2	3	4	5	6	7	8	9
Technological											
1. Technological Experiences	0.689	1.643									
2. Investment Systems & Equipment	0.344	0.192	−0.07	−0.29							
Interorganizational											
3. Interorganizational Experiences	0.524	1.084	0.77	0.07	0.10						
4. Proportion Technological Exchange Relationships	0.017	0.107	0.67	0.09	−0.07	0.51					
Organizational Attributes											
5. General/Nontechnical Innovations	0.968	1.807	0.65	0.06	−0.09	0.25	0.47				
6. Size (Log assets in $ Millions)	3.648	0.438	0.54	0.31	−0.50	0.49	0.32	0.52			
7. Return on Equity, 3-year average (%)	12.645	4.843	−0.05	0.03	0.14	−0.09	−0.01	−0.11	0.01		
Industry Attributes											
8. Size of Demand	3.691	0.443	0.23	0.14	−0.01	0.22	0.17	0.31	0.36	−0.03	
9. Number of Banks in the State (Log)	2.333	0.467	0.01	0.12	−0.06	0.05	0.02	0.05	0.11	−0.11	0.53

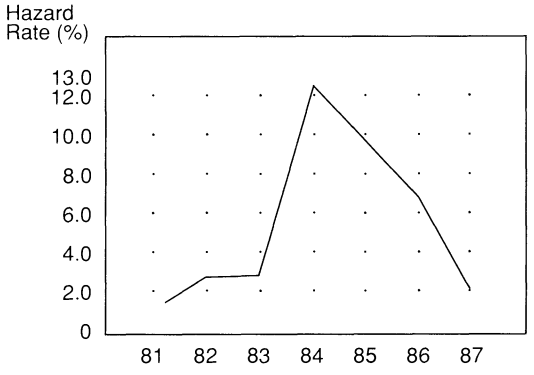


FIGURE 2. Estimates of the Rates of Entries into Videobanking Services.

TABLE 4

Distribution of Banks Venturing into Videobanking Services

Total	81	82	83	84	85	86	87	
Internal developments	2	3	1	4	4	3	2	19
Licensing/ Other agreements	1	2	2	10	2	6	1	24
Joint Ventures	0	0	1	1	4	0	0	6
Total	3	5	4	15	10	9	3	49

TABLE 5
Logistic Regression of the Adoption of Videobanking

Independent Variables	5.1	5.2
Intercept	−9.577***	−8.885***
	(2.327)	(2.197)
Technological Experiences	0.128	0.118
	(0.128)	(0.129)
Interorganizational Experiences	0.357**	0.410***
	(0.156)	(0.146)
Proportion Tech Exchange Relationships	2.256***	1.983***
	(0.820)	(0.776)
Investment, System & Equipment	−0.031	0.384
	(0.991)	(0.953)
Year 81 (Dummy)	0.049	
	(0.933)	
Year 82 (Dummy)	0.473	
	(0.824)	
Year 83 (Dummy)	0.701	
	(0.785)	
Year 84 (Dummy)	1.757***	
	(0.694)	
Year 85 (Dummy)	1.234*	
	(0.716)	
Year 86 (Dummy)	1.159	
	(0.729)	
Organizational Attributes		
General/Nontechnical Innovations	−0.131	−0.140
	(0.102)	(0.096)
Size	0.760	0.791*
	(−0.496)	(0.481)
Return on Equity	0.007	0.002
	(0.037)	(0.036)
Industry Attributes		
Size of Consumer Demand	0.684	0.692
	(0.508)	(0.490)
Number of Banks in State	−0.087	−0.083
	(0.449)	(0.440)
−2 log Likelihood	302.77	316.68
Chi-Squared (D.F. = 19)	74.33***	60.2***
Number of firm-years	870	870
Number of adoptions	49	49

Notes.
(1) Significance levels: * < 0.10; ** < 0.05; *** < 0.01.
(2) Standard errors are in parentheses.

banking ($b = 0.357$ and $b = 0.410$, with $p < 0.01$, respectively). Technological experiences do not have a significant effect ($b = 0.128$ and $b = 0.118$, respectively). Investment in systems and equipment has no significant effect either. Because the technological experiences and networking variables are collinear, they are somewhat redundant in explaining the event, as eliminating either of them from the model renders the other highly significant.[5]

[5]A collinearity diagnosis, yielding variance-decomposition proportions (Belsley, Kuh and Welsch 1980), revealed that technological learning was the only variable whose "tolerance" remained below the 0.2 level, where this level is deemed to be minimally acceptable. The variable had a tolerance level of 0.175 and a variance inflation of 5.71.

However, highly consistent with hypothesis 1 the proportion of technological exchange relationships is highly significant—both in the full model ($b = 2.256$, $p < 0.01$) and in the truncated one ($b = 1.983$, $p < 0.01$).[6] The more a firm gravitates toward those linkages that have an information technology content, the greater is its probability to innovate. The implication is that the building of such relationships engenders easier access to home banking, a service which blends multiple strains of technology.

The effects involving technological experience and interfirm networking were explored further by examining whether the effects were interactive. For example, it was determined whether the effect of the latter variable was a function of the level of technological experiences. The model was modified such as to replace either of the two experiences variables with the multiplicative term, incorporating both independent variables. The interaction effects remained inconclusive and did not add much to what models 5.1 and 5.2 reveal. Therefore this line of inquiry was not followed further. A model involving both main effects as well as the multiplicative effect yielded very high levels of redundancy and was not further explored either.

It is worthwhile to mention the pronounced effect of the 1984 dummy variable, a result that is consistent with the deregulation in the banking industry when the Federal Reserve Board permitted Citicorp to move into nonbanking services. The delayed effect of this decision is also discernible in 1985, although the lagged effect is not as strong as that for 1984. The comparison between model 5.1 and model 5.2 reveals the hazard rate to be time dependent. Comparing the model with and without the six dummy variables (i.e., 1981–1986) showed a significant ($p = 5\%$) chi-square difference of the 2 log likelihood at 13.09.

Table 5 shows further that larger banks are more innovative than smaller banks. The innovativeness variable did not relate to home banking. Recall that this variable was presumed to mirror a proclivity to financial innovation, but was not assumed to enhance an organization's propensity to innovate in areas of information technology. Return on equity did not have any bearing on home banking, even though high levels of profitability were presumed to generate more slack for innovation.

Finally, industry attributes have little bearing on the innovation decision. As previously mentioned, many innovation studies allude to size of demand or level of competition as precursors to innovation, but in this study such variables do not factor prominently in the explanation of innovation.

Organizational Form of Implementation

The second, and major, part of the inquiry pertains to the organization form with which banks implemented home banking. Table 6 presents the results. The dummy variables for the six years, along with the industry attributes, have been deleted from the model. This reduction in degree of freedom was necessary due to the lesser number of events in each of the two innovation categories. For example, among the 49 banks there are only 19 who realized home banking through internal venture. A model with many independent variables would render the maximum likelihood testing less viable.

Table 6 presents three models. Model 6.1 presents the results for the total sample, using this reduced model. Model 6.2 involves the analysis of internal implementation,

[6]Although this is beyond the scope of the paper, it may be of interest to note that, in a separate analysis, the effects of nontechnical interorganizational relationships (for example with other financial services firms) have also an effect on innovation, although not as strong as those involving relationships with computer hardware firms and software houses.

TABLE 6
Logistic Regression of Innovation Adoption Dependent Variable: Entry into Videobanking by Mode of Entry

Variable	Model 6.1 Full Sample	Model 6.2 Internal Arrangement	Model 6.3 External Arrangement
Intercept	−7.366***	−9.693***	−7.625***
	(1.775)	(3.045)	(2.137)
Technological Experiences	0.113	0.284*	−0.118
	(0.125)	(0.180)	(0.145)
Interorganizational Experiences	0.404***	−0.019	0.653***
	(0.145)	(0.278)	(0.176)
Proportion Technological	1.974***	2.494**	2.085**
Exchange Relationships	(0.764)	(1.103)	(0.931)
Investment, Systems & Equipment	0.399	−0.800	1.019
	(0.963)	(1.819)	(1.102)
Organizational Attributes			
General/Nontechnical Innovations	−0.123	−0.132	0.110
	(0.094)	(0.155)	(0.107)
Size	1.034**	1.171*	1.018*
	(0.458)	(0.728)	(0.556)
Return on Equity	0.004	0.096	−0.022
	(0.037)	(0.087)	(0.037)
−2 Log Likelihood	318.73	138.67	231.32
Chi-Squared (D.F. = 10)	58.37***	35.20***	34.98***
Number of firm-years	870	838	852
Number of adoptions	49	18	31

Notes: (1) Significance levels: $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.
(2) Standard errors are in parentheses.
(3) The difference in number of cases in last two columns is due to the omission of videotex adopting banks who did not have the form of adoption involved.

while model 6.3 covers external ones. The differences in number of degrees of freedom in the last two columns are due to the deletion of banks, whose form of implementation does not apply.

The variable, proportion of technological exchange relationships, continues to be a strong, and significant, innovation predictor, regardless of the type of organizational arrangement which harbors the innovation. This applies to the full model ($b = 1.974$) as well as the one concerning the internal ($b = 2.494$ in model 6.2) versus external ($b = 2.085$ in model 6.3) form. This result is important. The predictor stands for the intensity of technological networking with other firms and appears to be very significant in the commercial banking sector. This finding provides additional strong support for hypothesis 1.

A major result involves the differential (model 6.2 versus 6.3) effect of technological and interorganizational experiences. The relative redundancy (as inferred from the product moment correlation) of these two variables in explaining innovation gets partitioned into the direction of the hypothesis. Technological experiences magnify the probability of home banking through internal form ($b = 0.284$, $p < 0.10$ in model 6.2). Banks with limited tradition of networking but considerable proprietary technological experiences implement home banking internally. In contrast, prior networking is conducive to external forms of implementation ($b = 0.653$, $p < 0.01$ in model 6.3); in short, these results support hypothesis 2. This finding is further reinforced by the finding, not presented here, that cooperative experiences with financial competitors and other service providers (such as merchandising and publishing companies)

enhance the probability of interorganizational forms of implementation (Pennings and Harianto 1991).

Discussion

The main results of this study are consistent with the theory. A bank's technological and structural traditions inform us about their propensity to innovate in a certain direction. Their history indicates also that some maintain full control by implementing home banking internally while others opt for some strategic alliance with other firms. Because the research is longitudinal, we feel confident to conclude that the implementation of home banking follows from an evolutionary process in which a bank's internal and extramural skills are crucial.

The more banks have amassed information technological skills, as derived from cumulative technological experiences, the greater their likelihood of home banking. Similarly, the more they have accumulated networking skills, as inferred from the magnitude of strategic alliances, the higher the probability of innovation. The empirical results showed there to be some overlap between technological experiences and interfirm networking. This in itself should not surprise us, because some linkages are created for undertaking projects involving information technology. Inclusion of both variables in one regression equation renders each one of them somewhat redundant. The predictive power of a third variable, capturing ingredients of both networking and technology (i.e., proportion of technological linkages), suggests that extramural sources of know-how are indeed conducive to the implementation of "hybrid" innovation. Networking enhances the odds of technological innovation, but the results show that alliances around information technology magnify this probability even more. The proportion of technological linkages figures most prominently in our estimation.

Strong support was found for hypothesis 2, that banks with a limited networking tradition innovate internally. In contrast, external forms were more prone to provide an innovation context for banks rich in networking skills. Larger banks are more innovative—a finding that is consistent with earlier innovation research (Rogers 1983). Level of competition and size of demand did not have an effect.

It was not clear why the investment in equipment and systems failed to receive support. The variable is intended to capture learning by doing. Perhaps the variable captures too broad a range of hardware, because it included not only investments in computers and telecommunication equipment, but also office furniture, typewriters and the like. Currently available data do not permit a more specific measure of learning by doing.

It may seem almost too plausible to expect cumulative technological experiences and networking to be precursors of innovation. What was not as plausible was that interfirm networking for the sake of information technology shows an exceedingly strong effect. It forces us to conclude that a firm can greatly improve its innovative capacity by leveraging the skills of others. Such a result drives home an important point: We should not confine innovation research to the single organization. Moving the analysis to the level of the "organization set" (Evan 1966) will improve our understanding of organizational innovation.

It should be emphasized that this paper did not make an attempt to account for the incidence of home banking, or the relative magnitude of organizational forms. The focus is on technological innovation and form of adoption by the focal organization in its "organization set" (Evan 1966), not an effort to survey diffusion of a new gadget among a set of U.S. banks. The design consisted of what Schlesselman (1982) calls the case control method. First, we compared innovators with noninnovators. Second, we

extended the comparison to forms of implementation. The intercepts of the models presented do not convey accurately the incidence of this innovation in the U.S. The estimate of the incidence is biased in relation to the proportion of innovators. The estimates of the independent variables, however, are not affected by the retrospective selection procedure of this study. Of course these were the estimates that satisfied the main objective of this study.

Internal versus External Innovation in Banking

The banking sector is distinctive regarding its absorption of information technology (Scherer 1982). The significance of technological networking in the regression analyses is therefore not unexpected. Any "cosmopolitan" (Gouldner 1957) organization can be expected to be more innovative, simply because its members are exposed to more stimuli. If interfirm networking can be construed as cosmopolitanism, this statement applies all the more when extraneous technological developments are forced upon the firm. Strategic alliances enable the actual confluence of various strains of technology. The banking sector appears to be a setting where these conditions occur, because it is a major buyer of information technology.

Our findings regarding internal corporate venturing are less specific, since firms disclose less information about internal, covert activities. In spite of encroachment of external technologies, some firms in this sector continue to preserve internal control over innovative efforts. The present data do not permit unequivocal conclusions about their motives; we impute a disinclination to partner with other firms, because they have comparatively few skills in implementing innovation externally. Another explanation is institutional isomorphism (DiMaggio and Powell 1983): some banks delay their mimicking of new institutional practices, but eventually will join the bandwagon (Abrahamson and Rosenkopf 1990). A second explanation is that home banking goes to the heart of retail banking—a core activity for most banks in this study; consistent with Burgelman (1983) prescriptions, home banking should therefore remain within the purview of management's control. Apart from possible motives, internal versus external forms of innovation present interesting thoughts on the structural conduciveness of hybrid innovations.

Organizational Form

In this study, in-depth information on "form" is somewhat limited. It is clear, however, that the results inform us about an innovative firm's structural inclinations. In addition to limits of its repertoire of structural skills, the choice of form might also be constrained by contingency factors. At the present time, developments around structural contingency theory (Burns and Stalker 1961) are stagnant, and we lack prescriptive theories about the sort of designs that promote or impede innovations.

Clearly, there is the need for follow up with a range of internal and external designs as these may differ on their capacity to generate new know-how, or provide divergent degrees of know-how transfer into the technological core of the organization. Argyris and Schon (1978) describe organizations which created new internal subunits whose innovative output was phenomenal, yet too far removed from the organizations' core skills. The final result was either the elimination of the unit, or a reorganization that rendered the unit more proximate to the rest of the organization. Burgelman (1984) provides nine types of ventures, with their choice predicated on strategic relatedness and importance. Powell (1990) speculates on a multitude of hybrid interfirm structures, and on how those structures become institutionalized. Unfortunately, much of the research to date has been of the arm chair or case study variety. Ideally, we should now proceed to broader studies on intra- and interorganizational cumulative experiences, and to fully recognize the historical foundations of

organization design. In other words, we need dynamic, historically grounded contingency theories which fit the technological and structural transformations at the firm and at the technology level.

Perhaps, the results reported here might give a new impetus to structural contingency theory. We sorely need prescriptive models for designs that are optimal for innovation. A next research would explore the ways in which firms "fill in the blanks" of internal and external forms that remain unexamined in this study.

It is conceivable that external forms of implementation are more congruent with hybrid innovations, because new interfirm units can be staffed with individuals, not saddled with computer or banking skills; they start with a clean slate. Experimentation with micro-electronic service delivery, unencumbered by traditional "routines" (Nelson and Winter 1982) from the parent, might be more feasible if the implementation is done externally. Internal ventures may not engender the level of autonomy to experiment with new delivery systems to achieve more responsiveness to customer needs. It goes without saying that banks with extensive networking have a greater readiness to experiment with joint ventures. Joint ventures may be more optimal to a successful introduction of new technology that is too complex or too hybrid to be understood by its partners. Home banking is not only a technological innovation, but an "architectural" innovation as well (Henderson and Clark 1990). As an "off-shore" unit, the innovation faces fewer legitimacy problems, will be evaluated on different criteria and becomes anchored in routines that fit the new service.

If structural contingency permits a limited discretion to choose designs, the present findings drive home an important point: the range of design options is not only dictated by technological or environmental requirements, but also by the repertoire of design skills which firms have accumulated. Such discretion pertains to both internal and interfirm arrangements.

Bank-Specific Implications?

It has been stipulated that the commercial banking sector might be symptomatic for many sectors in the service component of western societies. Strictly speaking, the present study is a "case study" of a single sector, which needs to be supplemented by other studies. Criteria for selection are variations in technological convergence, rates of technological innovations, "intrapreneurship" and strategic alliances, but should also include the manufacturing sector. It was already pointed out that airlines and telephone companies fit some of these criteria.

A comment should also be made on the contention that home banking is seen as a "failing" innovation, in the sense of poor consumer acceptance, a hostile regulatory environment and high levels of early attrition on the part of participating banks.

This study involves an innovation at the boundary of financial services organizations. Compared with manufacturing, the customer is often drawn into the production and delivery of the firm's output. Prescriptive models for the design of boundary spanning systems that are optimal in meshing the needs of the organizations and their clients are still lacking. Home banking is a major intrusion into the traditional client-organization interface and requires both the bank and its clients to "re-invent" (Rogers 1983) this innovation. Given that several banks have exited videotex, one might infer that some banking managers had not accomplished its successful re-invention. Similarly, the initially cool reception on the part of customers indicates that customers, too, find it difficult to understand this innovation's potential.

Ideally, we should conduct multiple-level studies, encompassing several sectors, so that innovation diffusion can be traced to both organization endogenous as well as exogenous factors. There is obviously the need to replicate this study on other innovations, involving organizations that lean toward internal and external forms of

implementation. While Mohr (1982) argues that each and every organizational innovation requires a middle range theory that is congruent with the unique precursors of a particular innovation it remains to be seen whether innovation research can move from the narrow or mid-range level to a more general level.

While this is a study of U.S. banks and their innovative behaviors, the results should also have relevance for many other sectors and countries. This applies particularly to those settings where several strains of technology are coming together, and where interfirm networking predominates. These include manufacturing sectors such as bio-technology versus pharmaceutical firms, semiconductors versus machine tool, manufacturing and watch industries and other industries showing a micro-electronic "sweep" (Mohr 1987). Converging technologies are particularly interesting to observe in the service sector, the sector which has been neglected by most innovation researchers. Examples include health care providers, airlines and telephone companies. These types of firms require extensive interfirm coordination for the delivery of services rendering them relatively proximate. Lateral networking might spill over into vertical networking. They also display major structural innovations, for example health maintenance organizations, reservation systems and telephone exchanges. Those service sectors provide an interesting opportunity for determining whether our findings are sector specific. It would seem plausible that those organizations which pioneered in such new, but traditionally alien technologies, and which have been partnering with pertinent organizations, enjoy an edge in coping with the micro-electronic sweep. The study has therefore a bearing on all those innovation research efforts which mirror the trial and error of organizations in the attempt to expand their design heuristics to construct organizational arrangements, that improve their capacity to implement an innovation.

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Appendix A. List of Banks in the Sample

1 Allied Bank of Texas
2 AmeriTrust Co., NA
3 Amoskeag Bank
4 AmSouth Bank NA
5 Arizona Bank
6 Banco de Ponce
7 Banco Popular de Puerto Rico
8 BancOhio National Bank
9 Bank of America NT & SA
10 Bank of Boston Corp
11 Bank of California NA
12 Bank of Hawaii
13 Bank of Mississippi
14 Bank of New England NA
15 Bank of New York
16 Bank of Oklahoma Tulsa NA
17 Bank of Virginia Co.
18 BancOne Corp
19 Bank South NA
20 Bankers Trust Co.
21 Banks of Mid America Inc.
22 Barnett Banks of Florida
23 BayBanks Inc.
24 Boatmen's Bancshares Inc.
25 Branch Banking & Trust Co
26 California First Bank
27 Central Bank, San Francisco
28 Central Jersey Bank & Trust
29 Chase Manhattan Bank, NA
30 Chemical Bank
31 Citibank N.A.
32 Citizens Fidelity B & Trust Co
33 Citizens First National Bank
34 Citizens & Southern N'l B of FL
35 City National Bank
36 Colorado N'l Bancshares Inc.
37 Comerica Bank-Detroit
38 Commerce Bank of Kansas City

39 Commerce Union Bank
40 Continental Bank
41 Continental Illinois N'l B & T
42 Corestates Financial Corp.
43 Crocker National Corp.
44 Cullen Frost Bankers Inc.
45 Deposit Guaranty N'l Bank
46 Dominion Bank NA
47 Equibank, Pittsburgh
48 Equitable Bank NA
49 Exchange National Bank
50 Fidelity Bank NA
51 Fifth Third Bank
52 First Alabama Bank
53 First American National Bank
54 First Citizens Bank & Trust
55 First City National Bank
56 First Eastern Bank NA
57 First Empire State Corp.
58 First Florida Bank NA
59 First Interstate Bancorp
60 First Kentucky National Corp
61 First Maryland Bancorp
62 First National Bank, Akron
63 First National Bank, Atlanta
64 First National Bank, Chicago
65 First National Bank, St Paul
66 First National Bank of Commerce
67 First Nat'l Bank of Maryland
68 First Pennsylvania Bank NA
69 First Republic Bank Dallas NA
70 First Security Corp
71 First Tennessee Bank NA
72 First Union National Bank
73 First Virginia Bank
74 First Wisconsin National Bank
75 Florida National Bank
76 Harris Trust & Savings Bank
77 Horizon Bank NA
78 Huntington National Bank
79 Indiana National Bank
80 Irving Trust Co
81 Jefferson National Bank
82 Key Bank NA
83 Liberty National Bank & Trust
84 Louisiana National Bank
85 Manufacturers Hanover Trust
86 Manufacturers National Bank
87 Marine Bank NA
88 Marine Midland Bank NA
89 Mark Twain Bank
90 Maryland National Bank
91 MBank Dallas NA
92 Mellon Bank NA
93 Mercantile Bank NA, St Louis
94 Merchants National Bank & Trust
95 Meridian Bank
96 Michigan National Bank
97 Midlantic National Bank
98 M & I Marshall & IIsley Bank
99 National Bank of Commerce
100 National Bank of Detroit
101 National City Bank
102 National Community Bank
103 NBC Bank San Antonio NA
104 NCNB National Bank of FL
105 New Jersey National Bank
106 Norstar Bank NA, Buffalo
107 Northern Trust Co.
108 Norwest Bank Minneapolis NA
109 Old Kent Bank & Trust Co
110 Pittsburgh National Bank
111 Provident Bank, Cincinnati
112 PSFS
113 Puget Sound National Bank
114 Rainier National Bank
115 Republic National Bank
116 Riggs National Bank, Wash. D.C.
117 R.I. Hospital Trust N'l Bank
118 Seattle-First National Bank
119 Security Pacific Nat'l Bank
120 Shawmut Bank of Boston NA
121 Society Bank NA
122 Southeast Bank NA
123 Southern National Bank
124 SouthTrust Bank of Alabama NA
125 Sovran Bank NA
126 State Street Bank & Trust Co
127 Summit Trust Co
128 Sun Bank Miami NA
129 Sunwest Bank of Alburqueque NA
130 Texas American Bank Fort Worth
131 Texas Commerce Bank NA
132 Third National Bank
133 Toledo Trust Co
134 Trust Company Bank
135 Union Planters National Bank
136 Union Trust Co
137 United Bank of Denver NA
138 United Carolina Bank
139 United Jersey Bank
140 United Missouri B. of Kansas Ct
141 United States Trust Co
142 United Virginia Bank
143 U.S. National Bank of Oregon
144 Valley National Bank
145 Valley National Bank, Passaic
146 Wachovia Bank & Trust Co
147 Wells Fargo Bank NA
148 Westamerica Bank NA
149 Whitney National Bank
150 Wilmington Trust Co
151 Worthen Banking Corp.
152 Zions First National Bank

Appendix B. List of Videobanking Ventures

No.	Bank	Year	Mode	Scope	Partner(s)
1	Arizona Bancwest	1985	I.D.	Limited	
2	BancOhio	1985	I.D.	Limited	
3	Bank America	1981	I.D.	Integrated	
4	Bank of Hawaii	1985	I.D.	Limited	
5	Bank of New York	1987	I.D.	Limited	
6	BancOne Corp.	1981	L/A	Integrated	OCLC Later: VFS
7	Barnett Banks, FL	1984	L/A	Integrated	ADP
8	California First	1983	L/A	Limited	Cox Cable 1987: PTC
9	Chase Manhattan	1981	I.D.	Integrated	Later: VFS
10	Chemical Bank	1982	I.D.	Integrated	Later: Covidea
11	Citibank	1982	I.D.	Integrated	Later: CNR
12	Citizens First	1984	I.D.	Limited	
13	Continental IL.	1984	L/A	Integrated	ADP
14	Corestates	1985	I.D.	Limited	
15	Crocker National	1982	L/A	Integrated	Chemical's Pronto
16	First American	1984	L/A	Integrated	ADP
17	First Bank Systems	1982	I.D.	Limited	Later: VFS
18	First Chicago	1985	J.V.	Integrated	VFS
19	First N. Atlanta	1986	L/A	Limited	Harbinger
20	First Tennessee	1986	L/A	Integrated	Covidea
21	First Union	1984	L/A	Integrated	ADP
22	First Wachovia	1985	J.V.	Integrated	VFS
23	First Wisconsin	1984	L/A	Integrated	ADP
24	Florida National	1982	L/A	Integrated	Chemical's Pronto
25	Horizon Bank	1984	I.D.	Limited	
26	Huntington National	1984	L/A	Integrated	CompuServe
27	Key Banks	1987	L/A	Integrated	Trintex's Prodigy
28	Louisiana National	1986	L/A	Integrated	Shuttle Corp
29	Manufacturers Hanover	1985	I.D.	Limited	
30	Marine Midland	1984	L/A	Integrated	
31	Maryland National	1987	I.D.	Limited	
32	MBank	1986	I.D.	Limited	
33	Merchant National	1986	L/A	Limited	PTC
34	National City Bank	1984	L/A	Integrated	ADP
35	NCNB	1985	J.V.	Integrated	VFS
36	National Bank Detroit	1984	L/A	Limited	Applied C./ Telelogic
37	P.N.C.	1986	I.D.	Limited	
38	P.S.F.S.	1985	J.V.	Integrated	VFS
39	Security Pacific	1984	J.V.	Integrated	VFS
40	Shawmut	1985	L/A	Integrated	Chemical's Pronto
41	Signet/Bank of VA	1984	I.D.	Limited	
42	Society National	1984	L/A	Integrated	ADP
43	Southeast Banking	1983	L/A	Integrated	ADP
44	State Street B & T	1983	J.V.	Integrated	VFS
45	Third National	1984	L/A	Integrated	ADP
46	Toledo Trust	1983	I.D.	Limited	Later: Quadstar
47	Union Trust	1986	L/A	Integrated	Chemical's Pronto
48	United Jersey Bank	1986	L/A	Integrated	Chemical's Pronto
49	U.S. Trust	1986	I.D.	Limited	

Known Videobanking Ventures Not In Our Sample:

50	American Security	1982	??	??	
51	Colonial Bancorp	1984	L/A	Integrated	ADP
52	People National	1984	L/A	Integrated	ADP
53	First Interstate	1981	L/A	Integrated	Source/ Radio Shack
54	Interfirst Bank	1986	??	??	
55	Madison National	1983	??	Limited	

Note. I.D. Internal Development.
L/A Licensing/Developmental Agreement/Other Agreement.
J.V. Joint Venture.
ADP Automated Data Processing Co.
VFS VideoFinancial Services (Joint Venture).
PTC Princeton Telecommunication Co.

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