Analyzing innovation adoption using a knowledge-based approach

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Abstract

We propose a new typology of organizational innovation based on the integration of theories of organizational learning and theories of knowledge. The three dimensions that we use to construct our typology of innovations are: tacit–explicit, systemic–autonomous and simple–complex. We, then, analyze the impact of these different types of innovations on the method of sourcing, cost of implementation, and innovation effectiveness. We propose that as innovations become more tacit, systemic and complex, they tend to be more internally sourced, more costly to implement, and more effective.

We test the hypotheses using innovations from the commercial banking industry. Data for this study were collected from multiple sources. The innovations were categorized into different types by a panel of experts. Data on method of sourcing, cost and effectiveness were collected from a sample of 101 banks. Our results showed that autonomous innovations were less likely to be internally sourced than systemic innovations; autonomous and complex innovations were more costly to implement than systemic and simple innovations. Explicit innovations were seen as more effective than implicit innovations. Implications for theory and practice are discussed. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Organizational knowledge; Innovation; Management of technology; Method of sourcing; Cost of implementation; Effectiveness

1. Introduction

The use of configurational approaches in organizational analysis has greatly enhanced our understanding of the complexity associated with many organizational processes (Meyer et al., 1993; Mintzberg, 1990; Miller and Friesen, 1984; Miller, 1996). The basic premise of a configurational approach is that organizational phenomena can be better understood by identifying and studying distinct, internally consistent clusters of processes rather than
by searching for consistent behavior among all organizational processes. Downs and Mohr (1976) argued that the innovation process is one of the most complex organizational phenomena and a unitary theory of innovation was not acceptable because it led to empirical instability and theoretical confusion. Further, they suggested the development of innovation typologies to assist in our understanding of the innovation process. However, efforts to date in classifying innovations into distinct types have been somewhat unsuccessful because of inconsistencies in the research results (Wolfe, 1994; Fiol, 1996).

In this study, we try a different approach. Following Fiol’s (1996) suggestion to integrate research in the areas of organizational innovation with advances in the area of organizational learning, we propose to classify innovations by the nature of the knowledge associated with the innovation process. Such a typology will shed light on one of the most critical dimensions of the innovation process: the integration of different knowledge areas during the adoption and implementation of the new idea. Research in this area is particularly timely as many recent advances in the area of strategic management are based on a knowledge-based view of the firm. According to this view, knowledge can be considered the most strategically significant resource of the firm because it is central to many organizational activities and processes such as management of technology, organizational learning, managerial cognition and organizational innovation (Grant, 1996).

This paper has two key objectives. The first is to develop a categorization of innovations based on the nature of the knowledge associated with them. In developing this typology, our intent is not to dismiss the importance of existing typologies, but instead, to strengthen them by devising a complementary classification scheme that can be used in conjunction with them. In this study, we demonstrate this complementarity by using our typology with both product and process innovations. The second objective is to demonstrate differences in the impact of the knowledge-based innovation categories on key organizational decisions and outcomes. The three decision–outcome variables, which are, method of sourcing, cost of implementation and innovation effectiveness, were selected based on their relative importance at different stages of the implementation process.

The transference and integration of knowledge is important to each of these areas, but in a different manner. External sourcing requires the ability to transfer outside knowledge into the organization and to integrate this new knowledge with the existing knowledge base. Cost of implementation is reduced if knowledge can be efficiently transferred across different groups within the organization. Innovations are most effective in creating a competitive advantage if the company can prevent competitors from transferring critical knowledge beyond the company’s boundaries.

2. Theoretical framework and research hypotheses

2.1. Organizational innovation

In the past 20 years, many potentially useful typologies have been proposed, each providing insight to our understanding of the innovation process. Three of the most popular typologies are based on the distinctions between administrative and technical innovations, product and process innovations, and radical and incremental innovations (Damanpour, 1991; Gopalakrishnan and Damanpour, 1997).
The distinction between administrative and technical innovations reflects a more general distinction between social structure and technology (Evan, 1966). Technical innovations include products, processes and technologies used to produce products or render services related to the basic work activity of an organization. Administrative innovations pertain to organizational structures and administrative processes and they are more directly related to the management of the firm (Daft, 1978; Damanpour and Evan, 1984; Damanpour, 1987, 1996). While technical innovations usually occur in the technical core and follow a “bottom-up” process of assimilation, administrative innovations are more often initiated in the administrative core and follow a top–down process of implementation (Daft, 1978).

Product and process innovations are distinguished based on the different areas and activities that each of them affect within the firm (Gopalakrishnan and Damanpour, 1997; Ettlie and Reza, 1992; Utterback and Abernathy, 1975). Product innovations are outputs or services that are introduced for the benefit of customers or clients; while process innovations are tools, devices, and knowledge in throughput technology that mediate between inputs and outputs (Utterback and Abernathy, 1975; Ettlie and Reza, 1992). Product innovations tend to occur with greater frequency earlier in a product’s life cycle while process innovations usually occur later (Utterback and Abernathy, 1975). Additionally product innovations are usually aligned with a differentiation strategy, while process innovations aid the effective implementation of a low-cost strategy (Porter, 1985; Butler, 1988).

Researchers also differentiate between radical and incremental innovations (Dewar and Dutton, 1986; Ettlie et al., 1984; Tushman and Anderson, 1986). This classification is usually based on the degree of change an innovation causes to the structure and processes of an organization (Damanpour, 1996). Radical innovations produce fundamental changes in the activities of an organization and produce clear departures from existing practices. Incremental innovations, on the other hand, call for marginal departure from existing products or processes and reinforce the existing capabilities of firms.

These typologies have helped us improve our understanding of the complexity associated with the organizational innovation process. However, none of these typologies explicitly address the characteristics of the knowledge associated with an innovation. Grant (1996) has argued that the understanding of how knowledge flows, and is integrated throughout an organization are critical capabilities to the improvement of a variety of organizational processes. The management of an organization’s knowledge base is especially important as environments become more turbulent (hypercompetition), there are more rapid technological changes, and organizational boundaries become blurred. Under these conditions, organizations must be flexible and organizations’ competitive advantages are largely based on their efficiency of knowledge integration (Grant, 1996; Volberda, 1996). Thus, we argue that classifying innovations according to the type of knowledge associated with the innovation, in addition to the extant typologies outlined above, will further enhance our understanding of the complexity associated with the innovation process.

2.2. Organizational knowledge

Research involving organizational knowledge has emphasized the importance of different types of knowledge and has focused on different social entities (e.g. individual, communities-of-practice, organizational, network). Unfortunately, there has been little
consistency in classifying knowledge. Probably the most common distinction is between tacit and explicit knowledge (Polanyi, 1966; Nonaka, 1994; Spender, 1994). Winter (1987) proposed six taxonomic dimensions of knowledge assets: tacit–articulable, not teachable–teachable, not articulated–articulated, not observable in use–observable in use, complex–simple, and an element of a system–independent. Lyles and Schwenck (1992) identified two characteristics of organizational knowledge structures: complexity and relatedness. Chesbrough and Teece (1996), while discussing which innovations or activities should be outsourced, differentiated between systemic and autonomous innovations, a concept similar to Lyles and Schwenck’s notion of relatedness. Kogut and Zander (1993), while conducting an empirical study analyzing MNC’s transfer of new products to foreign subsidiaries, used three dimensions of knowledge: codifiability, teachability and complexity. They also used the same scales in Zander and Kogut (1995).

For our study, we wanted to develop a typology that is consistent with much of the past research and also consolidates related research. Our focus is on categorizing the knowledge associated with specific innovations, which is a different focus than some of the other studies, such as Lyles and Schwenck (1992) that focus on an organization’s knowledge structure. Others (e.g. Kogut and Zander, 1992) have discussed how knowledge can be embedded in different social entities, ranging from small groups of individuals to networks of firms, but for each, specific individuals play critical roles in obtaining, transferring and memorizing knowledge. Following Whetten’s (1989) advice on theory development, we chose factors attempting to balance comprehensiveness and parsimony. Thus, we chose the following three dimensions: tacit–explicit, complex–simple and systemic–autonomous.

The tacit–explicit dimension is well established in the literature and is closely related to other dimensions of codifiability, teachability, observability and articulateness. In fact, others have used each of these terms in defining tacitness. Whereas tacitness is associated with whether knowledge can be transferred, the systemic–autonomous dimension focuses on the extent to which knowledge components are linked with other knowledge components and the complex–simple dimension focuses on the extent of sophistication of knowledge incorporated in the innovation. These three dimensions are comprehensive in that they incorporate most of the dimensions discussed by others listed above, and are parsimonious in that they all have been argued as being important in the literature.

We have identified three key decision parameters in the innovation adoption process as our dependent variables. They include method of sourcing, cost of implementation and overall effectiveness. The identification of these dependent variables help us to understand whether there are key differences in the innovation adoption process based on our knowledge-based typology.

First, we examine whether different types of innovations are sourced differently, which is a strategic decision made at the adoption stage. The nature of knowledge associated with an innovation may affect the decision of whether to (a) internally source, which refers to the adoption of knowledge developed predominantly within the boundaries of the firm, or, (b) externally source, which refers to the adoption of knowledge developed by others outside

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2 Badaracco’s (1991) classification of knowledge as migratory or embedded, and the distinction between knowing how and knowing about (Grant, 1996) are closely related to the more frequently used classification of tacit and explicit knowledge.
the boundaries of the organization. Internal sourcing of innovations help in the development of the firm’s core competencies and capabilities and allow the firm to appropriate more of the profits (Bierly and Chakrabarti, 1996a). External sourcing of innovations save the firm the cost of development and may increase the speed of implementing innovations (Kessler and Chakrabarti, 1996; Gold, 1987).

Second, we determine whether different types of innovations vary in their cost of implementation, which is at the implementation stage. Tornatzky and Klein (1982) illustrated that one of the weaknesses in the innovation literature was the over-emphasis on the decision to adopt an innovation with scant attention being paid to the problems associated with implementation. The cost of innovation implementation has strategic importance for several reasons: (a) an efficient product development process is a key element of a firm’s cost leadership strategy (Porter, 1985), (b) lower costs allow the firm more flexibility in pursuing a broader array of projects, and (c) an efficient process is a critical success factor for product innovation (Cooper and Kleinschmidt, 1987).

Third, we analyze which types of innovations are most effective in creating a sustainable competitive advantage, which is an output measure of both the adoption and implementation stages. Barney (1991) identified that a resource or asset can be a source of sustainable competitive advantage if it is inimitable, rare, valuable and not substitutable. Imitation is not just gaining access to the knowledge, it also requires an interpretation, understanding, and integration of the knowledge with the imitator’s own knowledge base. Cohen and Levinthal (1990) pointed out that this mode of external learning through imitation requires some prior knowledge in the area, which they refer to as “absorptive capacity”, to assist in the transfer. However, Kogut and Zander (1992) identified the major dilemma for strategic decision makers of an organization as the following: the same characteristics that make knowledge hard to imitate by competitors make it difficult to transfer within the organization and delay implementation of an innovation associated with the knowledge.

2.3. Innovations and tacit knowledge

Polanyi (1966) made a clear distinction between (1) explicit knowledge, which he defined as knowledge that is codifiable, able to be articulated, and thus can be communicated, and (2) tacit knowledge, which cannot be codified and articulated and is “personal”. He made the simple, but important, observation that in the case of tacit knowledge “we know more than we can tell”. This classification of knowledge, though vague, is widely used among researchers (Nonaka, 1994; Grant, 1996; Spender, 1994). The knowledge associated with tacit innovations is implicitly grasped and cannot be fully articulated. 3 Hands-on experience builds up an understanding of tacit knowledge (Nonaka, 1994). Therefore, it is difficult to pass on knowledge about these innovations to others outside the community-of-practice because they will not understand the terminology and basic principles associated with it.

Often, the transference of tacit knowledge requires informal communication methods, such as the use of stories or metaphors (Brown and Duguid, 1991). Thus, such innovations

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3 An innovation includes different knowledge areas, some may be tacit and others may be explicit. We refer to an innovation as being tacit when it incorporates more tacit than explicit knowledge. Similar terminology is used for the other knowledge dimensions.
may be very difficult, if not impossible, to externally source from another organization (Chesbrough and Teece, 1996). Internally sourcing this type of knowledge would also help the firm better understand and learn more about the specialized knowledge and create a core competence in the area (Grant, 1996). Firms tend to outsource explicit knowledge areas that can be easily codified, transferred and consequently assimilated into their existing knowledge base.

**Hypothesis 1.** The more explicit the knowledge associated with an innovation, the less likely it will be internally sourced.

The process of adoption of innovations based on more tacit knowledge is a challenging process because of the lack of codifiability and also because it is difficult to transfer learning from one innovation decision situation to another (Poole, 1981, 1983). This makes the implementation process more difficult to manage and costly, as compared to explicit innovations. Additionally, it is harder to integrate tacit innovations into other knowledge areas because of the difficulty of transferring knowledge across “communities-of-practice” within the firm (Brown and Duguid, 1991). This means that educating and training personnel to implement tacit innovations are costly and lengthy processes when compared to explicit innovations.

**Hypothesis 2.** The more explicit the knowledge associated with the innovation, the lower will be the cost of implementation.

When tacit innovations are successfully implemented, they are more effective in creating a sustainable competitive advantage than innovations based on explicit knowledge, because they are more difficult for competitors to imitate. Tacit knowledge is more inimitable because it cannot be articulated clearly to others and requires personal experience. Boundary spanners from competitors have difficulty in interpreting tacit knowledge without active participation in either its development, implementation or operation. Therefore, the benefits from tacit innovations are more appropriable to the firm that generates them (Teece, 1986); consequently they are perceived as being more effective than more explicit innovations.

**Hypothesis 3.** The more explicit the knowledge associated with an innovation, the lower will be the perceived effectiveness of the innovation.

2.4. Innovations and systemic knowledge

Chesbrough and Teece (1996) defined autonomous innovations as those that can be developed and implemented independently from other innovations and organizational processes. Systemic innovations could be implemented only in conjunction with related, complementary innovations. An innovation can be viewed as autonomous if it can be developed and

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4 The rationale that innovations based on tacit knowledge are difficult to externally source assumes that the community-of-practice is predominantly within the boundaries of the organization. For the majority of cases in our study this is a safe assumption. However, in cases where these individuals have similar professional training and backgrounds (doctors who are specialists), cross-organizational communities-of-practice are commonplace, and this rationale would be faulty. However, these arrangements are not common in the banking industry because of the considerable variability of professional background and training.
implemented as a “black box” and “plugged in” to related components or processes. The more the innovation is linked with other knowledge areas in an intricate manner, the more systemic it is.

The more systemic the knowledge contained in an innovation, the more difficult it is to out-source from another organization, primarily due to coordination challenges (Chesbrough and Teece, 1996). A systemic innovation requires a complete open exchange of information to facilitate the integration of the different knowledge areas. Unaffiliated companies linked through arm’s-length contacts often cannot achieve sufficient coordination because each company wants to gain more from the innovation and, therefore, is unwilling to share information freely. Every organization, due to lack of complete trust believes that the other will act in potentially opportunistic ways to further its own ends (Das and Teng, 1998). Clearly, open exchange of information is easier and safer in-house than between two different organizations. The inevitable conflicts and choices that arise as systemic innovations are developed and implemented can be best resolved by an integrated company’s internal management processes (Chesbrough and Teece, 1996). Network theorists (Quinn, 1992) have argued disaggregation and outsourcing can be beneficial because it is cost efficient and easier to control, particularly in non-critical tasks. We extend this to innovations that are more autonomous.

**Hypothesis 4.** The more autonomous the knowledge associated with an innovation, the less likely it will be internally sourced.

The coordination costs associated with systemic innovations are higher than those of autonomous innovations because the types of structural configurations and control mechanisms required for systemic innovations are more sophisticated and more expensive to put in place than those for autonomous innovations (Mintzberg, 1979). Successful implementation of a systemic innovation requires that many experts work together by combining their knowledge base. Irrespective of the method of sourcing, systemic innovations require greater integration of diverse knowledge areas through liaison personnel (Gailbraith, 1973; Mintzberg, 1979). Clearly, this also adds to the total cost of implementation of the innovation.

**Hypothesis 5.** The more autonomous the knowledge associated with an innovation, the lower will be the cost of implementation.

Lippman and Rumelt (1982) identified that “causal ambiguity” can sustain a competitive advantage; i.e. if components of a system are linked together in an intricate manner, it will be difficult for others to determine and imitate the source of the competitive advantage. Since systemic innovations have more causal ambiguity than autonomous innovations, greater effort is required to implement them successfully. However, when their adoption is completed, employees are likely to perceive greater benefits to be derived from them. On the contrary, more autonomous innovations are easier to implement and employees perceive them as conferring fewer benefits.

**Hypothesis 6.** The more autonomous the knowledge associated with an innovation the lower will be the perceived effectiveness of the innovation.
2.5. Innovations and complex knowledge

The distinction between complex and simple innovations has been made by many organizational theorists but many of the definitions of innovation complexity are broadly stated or vague (see Gopalakrishnan and Damanpour (1994) for a review). For example, innovation complexity has been defined as the degree to which an innovation is difficult to understand and use (Rogers, 1983; Zaltman et al., 1973). That definition is indistinguishable from the concepts of tacitness and inter-relatedness, because tacit and systemic innovations are also difficult to understand and use. Thus, following the lead of Pelz (1985), King (1992) and Gopalakrishnan and Damanpour (1994), we classify an innovation as complex or simple based on three specific characteristics: (1) the degree of difficulty, (2) the degree of intellectual sophistication, and (3) its originality.

We consider an innovation as complex if it is associated with knowledge that is sophisticated and difficult to understand. Sophistication is different from tacitness. A tacit innovation may be difficult to understand because the knowledge cannot be codified or easily communicated, but a sophisticated innovation is difficult to understand because it contains advanced technology. Additionally, innovations are more complex if they are more original. Original innovations will be perceived as more complex by organizational members because of the uncertainty associated with something new (Pelz, 1985).

Kogut and Zander (1993) found as technologies became more complex, firms tended to internally transfer them to their own subsidiaries. This was done in lieu of licensing out the technology to a third party. This implies that innovations and technologies that are more complex will be difficult to transfer to an outside party. Further, if an organization externally sources a complex innovation, it will not be able to develop the “absorptive capacity” to understand, interpret and fully utilize the outsourced innovation (Cohen and Levinthal, 1990). On the other hand, a simple innovation can be easily obtained from an outside source and typically is not worth the cost of development, if it is available elsewhere. Information about complex products and technologies often develop over time, as managers absorb new research findings, results of early experiments, and initial customer feedback (Chesbrough and Teece, 1996). The in-house development of complex innovations makes the organization personnel familiar with the difficult and original elements of the innovation and consequently reduces the uncertainty associated with its implementation process.

**Hypothesis 7.** The more complex the knowledge associated with an innovation, the more likely it will be internally sourced.

The adoption of complex innovations is more difficult and costly than the adoption of simple innovations. Complex innovations are usually associated with processes that are not linear and are associated with a series of feedback and feedforward loops (Kline, 1985). Failure at different stages is more likely for complex innovations than simple innovations, forcing the adoption team to retreat to an earlier stage. The implementation process of complex innovations tend to have more overlap between stages making the process seem more muddled (Pelz, 1985). On the other hand, simple innovations tend to be narrower in scope, have less potential for political opposition, and their adoption tend to follow a more orderly process (Gopalakrishnan and Damanpour, 1994). Generally speaking, the
implementation of complex innovations tend to be messy with multiple, cumulative and convergent, parallel and divergent streams of activity commonly termed as a ‘multiple sequence pattern of adoption’ (Schroeder et al., 1989; Poole, 1981, 1983). Implementation of simple innovations, on the other hand, tend to be more orderly, and follow what has been termed as a ‘unitary sequence pattern’ (Gopalakrishnan and Damanpour, 1994). Each of these differences in the processes associated with complex and simple innovations has the effect of forcing complex innovations to be more costly than simple innovations.

**Hypothesis 8.** The more complex the knowledge associated with an innovation, the higher will be the cost of implementation.

Complex innovations are harder for competitors to imitate mainly because competitors need to have an understanding of the advanced technologies associated with them. In addition, customers perceive complex innovations as being more valuable than simple innovations because they are more original and more sophisticated than simple innovations. This perception of value helps in building a customer orientation which in turn empowers customers (Lengnick-Hall, 1996). Following Barney’s (1991) argument, we can surmise that innovations, like resources, are more likely to confer competitive advantage to an organization when they are perceived by customers as rare, valuable and imperfectly inimitable. Complex innovations, when successfully implemented are likely to create a positive perception with the employees. Knowledge associated with the adoption of such complex innovations is more appropriable and, therefore, more likely to be a source of competitive advantage.

**Hypothesis 9.** The more complex the knowledge associated with an innovation, the higher will be the perceived effectiveness of the innovation.

3. **Research design and measures**

3.1. **The sample**

The data for this study were collected from commercial banks in four northeastern states (New York, New Jersey, Connecticut and Massachusetts) in the United States. Commercial banks were a particularly interesting sample to study for two reasons. First, the sophistication and cost of computer hardware and software used in the commercial banking industry has made this a very knowledge-intensive service industry. In the period between 1978 and 1982, the deregulation of the industry resulted in increased competition and a motivation to introduce innovations for competitive advantage in the 1980s. Therefore, this would be an interesting context to analyze the adoption and implementation of knowledge-intensive innovations. Second, financial service firms are particularly interesting examples to study the process of outsourcing and its effectiveness. With almost three quarters of all non-interest expenses lying in marketing and distribution, credit approval and funds movement, many outside suppliers have found ways to achieve economies of scale and effectively supply technology and innovations to banking institutions (Quinn, 1992).
We adopted Downs and Mohr’s (1976) innovation–decision design so that innovations of varying types were not all considered together. The current method of grouping together innovations by specific types enables us to draw meaningful conclusions about each type. For generation of our knowledge-based typology, we relied on expert categorization.

A mail questionnaire was used to collect details about the outcomes of innovation adoption and implementation. The questionnaire was sent to the senior executives of 365 banks, the entire population of banks in the four states as of January 1994. We received responses from 110 banks, 101 of which were complete and usable. Telephone calls to approximately 50 banks verified the direct participation of senior executives.

3.2. Data collection

Information about the innovation typology, source, cost and effectiveness was collected in three phases.

3.2.1. Development of the list of innovations

In the first phase, a literature search was conducted to generate a list of innovations introduced in the banking industry between 1982 and 1993. We selected 1982 as the starting point for the data collection because three major pieces of legislation that deregulated the industry were enacted between 1978 and 1982. These three pieces of legislation — The Financial Institutions Regulatory and Interest Rate Act of 1978, The Deposit Institutions Deregulation and Monetary Control Act of 1980 and the Garn-St. Germain Act of 1982 — greatly increased the competition in the commercial banking industry and increased the need for banks to innovate to achieve competitive success. A library search was conducted under six headings — new technology, new products, electronic banking, electronic funds transfer, banking systems and new financial services. Both popular and academic banking journals were included in the search. This search yielded a list of 40 innovations.

3.2.2. Expert surveys

The experts were surveyed in two phases. In the first phase, 11 experts who worked as bankers, bank consultants, members of state banking institutions and journalists in bank research magazines reviewed the innovations to validate their importance. Based on the expert interviews 11 innovations were dropped because they were either duplications of others in the list, or because they were insignificant. Two new innovations were added, resulting in a final list of 31 innovations (see Appendix A for a complete list of 31 innovations). We compared this list to those generated by other studies of innovation in the banking industry (Bantel and Jackson, 1991; Steiner and Texeira, 1990) and found no significant omissions. In the second phase, five experts who were either commercial bankers or academics reviewed the list of innovations and categorized them based on their knowledge content, into tacit or explicit, systemic or autonomous, and simple or complex innovations.

3.2.3. The field survey

A survey questionnaire was developed and pre-tested among 10 individuals with banking experience. Modifications were made to some innovation labels to improve their clarity. Two copies of the questionnaire were mailed to the CEOs of small and medium sized banks and
to the heads of retail, commercial and technology divisions of the large banks (25 banks) in
the spring of 1994. Large banks were treated differently on the assumption that the heads
of specialized units would be better able to provide accurate data on the adoption of innovations
in their respective units. About one and a half months later, a second set of questionnaires
was sent out to the banks that had not responded. A total of 101 usable responses were
received.

Of the 101 banks that responded, 35 banks sent multiple responses. We computed the
inter-rater reliability by calculating the percentage agreements between the two respondents
(Bolton, 1992). The inter-rater reliability was 0.67 on the cost of implementation and 0.69
on innovation effectiveness and 0.72 on method of sourcing.

3.3. Operationalization of the variables

3.3.1. Innovation typologies

We initially asked a total of nine questions of the experts to categorize innovations
based on their knowledge content. Three items to measure complexity were previously
used by others (Pelz, 1985; King, 1992) and generally accepted as valid. The remaining
six items to measure tacitness and autonomy were selected after a pretest given to 16
graduate students following the procedure proposed by Anderson and Gerbing (1991).5
Following the expert survey, we removed two additional items because of lack of agree-
ment among the experts. Finally, we had a total of seven questions to measure the three
constructs.

3.3.1.1. Tacit–explicit. Innovations were classified by the experts as explicit when the
knowledge contained in them could be accurately explained by manuals or documents and
when it was easy to train personnel for those innovations. The sum of the scores of questions
1 and 2 (Appendix B) was used to measure the explicitness of an innovation.6

3.3.1.2. Systemic–autonomous. Innovations were categorized by the experts as autono-
mous when the knowledge contained in them was independent of other innovations, when
the users could be relatively independent of contact with others in the organization, and
when operators of the innovations could operate the innovation independently. The sum of
the scores on these three items (questions 3–5, Appendix B) was used to identify the extent
of autonomy of an innovation.7

3.3.1.3. Simple–complex. Innovations were classified by the experts as complex when the
knowledge contained in an innovation was difficult to implement, when it was intellectually

5 Each of these six items was correctly assigned to their intended construct by more than 63% of the respondents.
6 The scores for this dimension were constructed so that higher scores indicated that an innovation contained
more explicit knowledge. The Spearman Brown coefficient which measured inter-rater reliability was 0.52 and
the Cronbach’s α was 0.93.
7 The scores for this dimension were constructed so that higher scores indicated that an innovation contained
more autonomous knowledge. The Spearman Brown coefficient which measured inter-rater reliability was 0.59
and the Cronbach’s α was 0.53.
sophisticated, and when the innovation was considered original. The sum of the last two questions (Appendix B) was used to identify whether innovations were simple or complex.\(^8\)

3.3.2. Source of innovation

This measure, collected from the bank respondents, attempted to capture whether innovations were developed internally or sourced externally. This was developed as a categorical variable where respondents were asked to categorize innovations into four categories. The first was internally sourced, the second was externally sourced idea that was significantly modified for use within the bank, third was replicated from a bank, and the last was replicated from a non-bank. The first two categories were grouped together as internally sourced (coded “1”) and the last two were grouped as externally sourced (coded “0”).

3.3.3. Cost of innovation

The bank respondents were asked to evaluate the relative cost of implementing each of the 31 innovations. The overall cost to initiate and implement the innovation was rated on a 5-point Likert scale where 1 was indicative of very low overall cost and 5 of very high overall cost.

3.3.4. Innovation effectiveness

The bank respondents were asked to evaluate the overall contribution of each of these innovations in meeting the goals and objectives of the bank. The effectiveness was evaluated on a 5-point Likert scale where 1 was equivalent to very low and 5 to very high.

3.4. Control variables

3.4.1. Organization size

To be consistent with other banking studies, we used total assets as the measure of size. Information for this variable was collected from Onesource\(^\text{TM}\), a database compiled by Sheshenuff Information Services for all federally insured commercial banks. The logarithmic transformation of total assets (US$ in '000s) was used as the measure of size because of the extent of skewness of the size measure over the sample.

3.4.2. Product versus process innovations

The experts grouped the innovations into 17 product and 14 process innovations based on the definitions supplied to the experts.\(^9\) On an average 85% of the experts agreed on the categorization of product innovations and 83% of the experts agreed on the categorization of the process innovations. Examples of product innovations include ATMs (in bank premises),

\(^8\) The scores for this dimension were constructed so that higher scores indicated that an innovation contained more complex knowledge. The Spearman Brown coefficient was 0.51 and the Cronbach’s \(\alpha\) was 0.70.

\(^9\) Product innovations were those innovations introduced to meet an external user or market need and process innovations were new elements introduced into an organization’s production or service operations (e.g. input materials, task specifications, work and information flow mechanisms, and equipment) to produce a product or render a service. This was analyzed as a categorical variable where product innovations were coded as “1” and process innovations were coded as “0”.
Table 1
Descriptive statistics of independent and dependent variables

<table>
<thead>
<tr>
<th>Study variables</th>
<th>Mean</th>
<th>S.D.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of explicitness</td>
<td>6.38</td>
<td>0.98</td>
<td>4.00</td>
<td>8.00</td>
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<tr>
<td>Degree of autonomy</td>
<td>10.68</td>
<td>1.00</td>
<td>9.00</td>
<td>12.25</td>
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<tr>
<td>Degree of complexity</td>
<td>5.69</td>
<td>0.97</td>
<td>4.00</td>
<td>8.75</td>
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<tr>
<td>Organization size</td>
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<td>7.89</td>
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<tr>
<td>Product–process(^a)</td>
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<td>0.50</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Method of sourcing(^b)</td>
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<td>0.48</td>
<td>0.00</td>
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<td>Cost of implementation</td>
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<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>3.56</td>
<td>0.96</td>
<td>1.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>

\(^a\) Product–process was operationalized as a categorical variable where product innovations were coded as “1” and process innovations were coded as “0”.

\(^b\) Method of sourcing was operationalized as a categorical variable where internal sourcing was coded as “1” and external sourcing was coded as “0”.

credit cards, and mutual funds; process innovations include truncation of the check handling process, high speed image processing of documents, and loan tracking system.

3.5. Data analysis

After banks identified an innovation as being adopted, they were asked to provide details on the source, cost and effectiveness. Information on source, cost and innovation effectiveness was collected from the survey questionnaire. While it would have been possible to have a maximum of 3131 adoptions had all 101 respondent banks adopted all 31 innovations, we had source data for 1218 innovations, cost data for 1240 innovations and effectiveness information for 1230 innovations. This resulted in an average of 12.18 innovations per bank.

Hypotheses 1–9 were analyzed using the results of regression analyses. In the case of the linear regression analyses, cost and effectiveness were used as the dependent variables (Table 4). Since we had multiple innovations from the one bank, we averaged each bank’s cost and effectiveness scores and then, deducted a specific innovation’s cost and effectiveness score from the bank’s average to get each innovation’s score on these variables. This provided cost and effectiveness information controlled by bank. A logistic regression was performed for method of sourcing because it was a categorical variable (Table 3). Additional models were created with the control variables (organization size and product versus process). Tables 1 and 2 present the means, standard deviations, ranges and correlations among the study variables.

4. Results

4.1. Tacit and explicit innovations

Hypothesis 1 proposed that the more explicit the knowledge associated with an innovation, the less likely it would be internally sourced (a negative correlation between
Table 2
Correlation matrix of the study variables

<table>
<thead>
<tr>
<th>Study variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of explicitness</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree of autonomy</td>
<td>-0.11***</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree of complexity</td>
<td>-0.14***</td>
<td>0.22***</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization size</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product–process</td>
<td>0.06**</td>
<td>0.27***</td>
<td>-0.39***</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method of sourcing</td>
<td>-0.04</td>
<td>0.07***</td>
<td>0.07*</td>
<td>0.17***</td>
<td>-0.10***</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of implementation</td>
<td>-0.05+</td>
<td>-0.05+</td>
<td>0.19***</td>
<td>0.16***</td>
<td>-0.27***</td>
<td>0.20***</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Effectiveness</td>
<td>0.08**</td>
<td>0.03</td>
<td>0.01</td>
<td>0.00</td>
<td>-0.11***</td>
<td>0.13***</td>
<td>0.11***</td>
<td>1.00</td>
</tr>
</tbody>
</table>

+ Level of significance: $P = 0.1$
* Level of significance: $P = 0.05$.
** Level of significance: $P = 0.01$.
*** Level of significance: $P = 0.001$.

explicitness and method of sourcing). The β coefficient in the logistic regression was in the expected direction (negative) and significant (Table 3: $β = -0.13$, $α = 0.05$) in Model 1. When we controlled for size and product–process (Model 2), the β coefficient was not significant.

Hypothesis 2 proposed a negative relationship between degree of explicitness and cost of implementation. While the correlation analysis provided some initial indication that more explicit innovations would cost less to implement than more tacit innovations (Table 2,

Table 3
Logistic regression models with source as the dependent variable

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explicitness</td>
<td>-0.13* (0.07)</td>
<td>-0.09 (0.07)</td>
</tr>
<tr>
<td>Autonomy</td>
<td>-0.20*** (0.07)</td>
<td>-0.14* (1.59)</td>
</tr>
<tr>
<td>Complexity</td>
<td>0.20** (0.07)</td>
<td>0.09 (0.08)</td>
</tr>
<tr>
<td>Organization size</td>
<td>0.38*** (0.07)</td>
<td></td>
</tr>
<tr>
<td>Product–process</td>
<td></td>
<td>-0.25*** (0.15)</td>
</tr>
<tr>
<td>-2 log likelihood</td>
<td>1566.376</td>
<td>1533.573</td>
</tr>
<tr>
<td>Goodness-of-fit</td>
<td>1218.061</td>
<td>1227.274</td>
</tr>
<tr>
<td>Model Chi-square</td>
<td>17.74***</td>
<td>50.55***</td>
</tr>
<tr>
<td>Predicted observation</td>
<td>64.7</td>
<td>67.9</td>
</tr>
</tbody>
</table>

a Coefficients (β) displayed with standard errors in parentheses ($N = 1218$).

b This was developed as a categorical variable where respondents were asked to categorize innovations into four categories. The first was internally sourced, the second was externally sourced idea that was significantly modified for use within the bank, third was replicated from a bank, and the last was replicated from a non-bank. The first two categories were grouped together as internally sourced (coded “1”) and the last two were grouped as externally sourced (coded “0”).

* Level of significance: $P = 0.05$.
** Level of significance: $P = 0.01$.
*** Level of significance: $P = 0.001$. 
Table 4
Regression models with cost and effectiveness as the dependent variables

<table>
<thead>
<tr>
<th></th>
<th>Cost ($N = 1241$)</th>
<th>Effectiveness ($N = 1231$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>Explicitness</td>
<td>−0.02</td>
<td>−0.01</td>
</tr>
<tr>
<td>Autonomy</td>
<td>−0.02</td>
<td>0.12***</td>
</tr>
<tr>
<td>Complexity</td>
<td>0.18***</td>
<td>0.05*</td>
</tr>
<tr>
<td>Organization size</td>
<td>−0.03</td>
<td></td>
</tr>
<tr>
<td>Product–process</td>
<td>−0.31***</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.03</td>
<td>0.10</td>
</tr>
<tr>
<td>Adj $R^2$</td>
<td>0.03</td>
<td>0.10</td>
</tr>
<tr>
<td>$F$</td>
<td>14.49***</td>
<td>28.90***</td>
</tr>
</tbody>
</table>

*a Standardized coefficients (β) displayed.
* Level of significance: $P = 0.05$.
** Level of significance: $P = 0.01$.
*** Level of significance: $P = 0.001$.

$r = −0.05, \alpha = 0.1$), this finding was not confirmed by the regression analysis. It is possible that some innovations that were explicit may rely on multiple types of knowledge areas, each of which may be explicit, but the entire innovation could be harder to integrate into the organization. This may increase the cost of implementation of explicit innovations and blur the differences in cost between tacit and explicit innovations.

Contrary to Hypothesis 3, innovations were perceived to be more effective as the knowledge contained in them became more explicit. This is evident from the regression analysis (Table 4, Models 3 and 4: $\beta = 0.10, \alpha = 0.001$). When innovations are explicit, they become more observable (Rogers, 1983). Questions about what the innovation is, and how the innovation works, are more readily available to individuals that use the innovation. As innovations become more explicit, it is easier to communicate information about these innovations, and consequently, the implementation process becomes smoother (Tornatzky and Klein, 1982); therefore, they were probably perceived as being more effective. It can be surmised that the advantages of tacit innovations may be harder for members of the organization to realize.

4.2. Systemic and autonomous innovations

Consistent with Hypothesis 4, innovations that were more autonomous tended to be less likely to be internally sourced. This was confirmed by the logistic regression analysis (Table 3, Model 1: $\beta = −0.20, \alpha = 0.001$). When organization size and product versus process type are considered as control variables, the effect of autonomy on the method of sourcing was somewhat reduced, but still significant (Table 3, Model 2: $\beta = −0.14, \alpha = 0.05$).

Hypothesis 5, which proposed that as innovations became more autonomous, the cost of implementation decreases (a negative correlation between degree of autonomy and cost of implementation), was not supported in the initial regression model (Table 4, Model 1).
However, in the model that controlled for size and product-process innovations (Table 4, Model 2) it seemed that more autonomous innovations were costlier to implement. We explored the data further and examined whether the relationship between degree of autonomy and cost was curvilinear and found that this may be one of the reasons for this result. As innovations get more autonomous they are less expensive to implement. But beyond a point, the costs start to rise. This could be because innovations that are completely autonomous may be viewed as very different than other products and processes of the organization, thus requiring more training and computer software to support.

Hypothesis 6, which predicted that as innovations became more autonomous, their effectiveness decreases, was not supported by the regression analyses. The $\beta$ coefficients in both Models 3 and 4 of Table 4 were not significant. It could be that both systemic and autonomous innovations were perceived to be effective for different reasons. On one hand, systemic innovations could be perceived as being effective because they are harder to implement and harder for competitors to imitate; on the other hand, the benefits of autonomous, stand-alone innovations may be more readily observed and therefore they could also be seen as effective. Consequently, there is little perceived difference in effectiveness across the two types of innovation.

4.3. Simple and complex innovations

Our study shows only partial support for Hypothesis 7, which proposed a positive relationship between degree of complexity and internal sourcing. While it is supported in the initial regression analysis (Table 4, Model 3: $\beta = 0.20$, $\alpha = 0.001$), when the control variables are introduced the effect of complexity on method of sourcing becomes insignificant. It seems that organization size and the product-process distinction are better indicators of the method of sourcing, as compared to the complexity of an innovation.

Hypothesis 8, which predicts a direct association between innovation complexity and cost of implementation, was supported by the regression analysis (Table 4, Model 1: $\beta = 0.18$, $\alpha = 0.001$ and Model 2: $\beta = 0.05$, $\alpha = 0.05$). However, the effect of complexity on cost is somewhat diminished by the control variables.

Contrary to Hypothesis 9, more complex innovations were not seen as more effective (Table 4, Model 1: $\beta = 0.01$ and Model 2: $\beta = -0.05$). We introduced a squared term and did an exploratory analysis and found that the relationship between complexity and effectiveness may be curvilinear.11 Thus, as complexity increases, the innovations are perceived to be less effective until a point, where the perception of effectiveness levels off and may actually start to increase. The negative correlation between complexity and effectiveness, over at least part of the relation, may be because more complex innovations are less readily understood by those implementing an innovation and, therefore, cause more

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10 We found that both degree of autonomy and the square of that term had a significant relationship with cost of implementation. The $\beta$ coefficient for the linear term was $-3.40$ and for the squared term was $5.06$. Both were significant at $P < 0.001$.

11 The linear and squared term of complexity was significant at $P < 0.01$. The $\beta$ for the linear term was $-0.55$ and for the squared term was $0.57$. 
uncertainty and fear (Rogers, 1983; Tornatzky and Klein, 1982). Consequently, they are not seen as being effective.

4.4. The effect of the control variables on innovation source, cost and effectiveness

Organization size had a significant positive relationship with the method of sourcing, (Table 3, Model 2). The relationships between organization size and cost of implementation, and size and effectiveness were not significant.

Process innovations were more likely to be internally sourced than product innovations. This was evident in the regression analysis (Table 3, Model 2: \( \beta = -0.25, \alpha = 0.001 \)). Process innovations were also more costly to implement (Table 4, Model 2: \( \beta = -0.31, \alpha = 0.001 \)); and were seen as more effective (Table 4, Model 4: \( \beta = -0.12, \alpha = 0.001 \)).

5. Discussion

The primary contribution of this paper is that we introduced and provided partial support for the development of an organizational innovation typology using a knowledge-based approach. The nature of knowledge associated with the innovation influences, at least partially, sourcing decisions, the cost of implementation, and the perceived effectiveness of the innovation. Drawing on the theoretical work of others, we categorized innovations based on three dimensions of knowledge: tacit–explicit, systemic–autonomous, and complex–simple. We examined the impact of these innovation types on innovation adoption parameters such as sourcing decisions, cost of implementation, and the perceived effectiveness of the innovation.

The intent of this exploratory study was to integrate and expand previous research in the areas of organizational innovation and organizational learning. The most challenging and innovative part of this study was the identification and quantification of dimensions of organizational knowledge. The notion of knowledge is very abstract and complex. However, we were successful in finding some initial differences using our three dimensions. We feel this is a major first step in an exciting area of research that clearly needs to be studied further.

5.1. Internal versus external sourcing

All three of our dimensions of knowledge seemed to be initially associated with sourcing in the proposed direction, based on the logistic regression analyses. However, when the control variables were included the strongest predictor of method of sourcing was the distinction between systemic and autonomous knowledge. Innovations that are based on systemic were more likely to be internally sourced.

The internal sourcing of process innovations, which were generally tacit, systemic and complex, somewhat enhances support for our theory. The underlying rationale for the internal sourcing of innovations of systemic innovations is two-fold. First, it is difficult to transfer systemic knowledge across organizational boundaries, understand its strategic importance, and efficiently integrate its use with other knowledge areas. Firms, therefore, need
to build up absorptive capacity particularly for systemic areas of knowledge, more than for autonomous knowledge. Second, when knowledge is internally developed, it tends to be more proprietary and firm-specific. Therefore, it will be difficult for competitors to imitate innovations based on systemic knowledge, as compared to those based on autonomous knowledge. Therefore, these types of innovations are more likely to lead to a sustainable competitive advantage. This is consistent with Quinn and Hilmer (1995) advice to internally develop innovations and technologies that will lead to a core competency and a sustainable competitive advantage and outsource activities that have less strategic importance and can be easily imitated.

It should be pointed out that the knowledge dimensions only explained a small percentage of the variance in the method of sourcing. Organization size and the distinction between product and process innovations were strong indicators of an organization’s method of sourcing. Thus, the knowledge typology proposed here assists in improving our understanding of sourcing decisions, but it should be used in conjunction with other innovation-related and organization-related variables.

5.2. Cost of innovation implementation

Of the three knowledge dimensions analyzed, the degree of complexity and autonomy clearly appear to be stronger indicators of cost of implementation than the tacitness of an innovation. Additionally, process innovations, which are usually tacit, systemic and complex, generally cost more to implement than product innovations, further supporting our general arguments about the higher cost associated with these types of innovations. The main reasons for these findings, as we had discussed earlier, are: (1) the increased coordination costs, (2) the higher costs of educating and training personnel, (3) the difficulty in transferring learning from one innovation decision situation to another (Poole, 1983), (4) the lack of codifiability, and (5) the difficulty of integrating the new knowledge with other “communities-of-practice” within the organization (Brown and Duguid, 1991).

Together, these results help us understand the varying costs of implementation for different innovations. However, there is still a large amount of unexplained variance. The remaining variance is probably explained by other organization-specific variables not included in this study. For example, organizational structure, and specifically the use of cross-functional teams, probably influences cost. Additionally, Kessler and Chakrabarti (1996) propose that innovation speed and quality are related to cost. The opportunities for further research in this area are certainly abundant.

5.3. Effectiveness of innovations

The most surprising findings of this study were the relationships that we observed between our three knowledge dimensions and innovation effectiveness. There are three issues that will help to clarify these findings. First, the relationships between the three dimensions and effectiveness were weak as seen in the regression analysis. A deeper analysis of the data revealed that many executives were somewhat biased in their evaluation of innovation effectiveness because effectiveness was more of a value judgment about their company, than either cost or method of sourcing. Consequently, they rated most implemented innovations
as being either “somewhat effective” or “very effective”. This limited variation was partially responsible in innovation type having a very weak link with innovation effectiveness.

Second, contrary to our expectations, innovations based on explicit knowledge were seen to positively impact effectiveness. As mentioned earlier, when compared to tacit innovations, innovations that were explicit were easier to understand, caused lesser uncertainty among employees and generally followed a smoother implementation process (Tornatzky and Klein, 1982; Rogers, 1983). Therefore, although tacit innovations may indeed provide greater substantive benefits leading to a competitive advantage, explicit innovations were perceived as being more effective because of employees’ positive experience with the innovation.

Third, while tacit knowledge is more difficult to acquire, it is also more difficult to question or “unlearn”. In an environment, like the United States banking industry, where a paradigm shift is taking place because of industry deregulation, the existing tacit knowledge may be out of sync with the emerging realities. Therefore, innovations based on tacit knowledge may be less likely to create a competitive advantage in an environment experiencing discontinuous change, and more likely to create competitive advantage in a relatively steady-state environment.

Many interesting questions have been raised about factors that can explain innovation effectiveness. It is clear from the findings of this study, that we may need to examine other innovation and context-specific variables to explain effectiveness. Further, these variables may indeed have different kinds of influence on perceptual versus objective measures of performance.

5.4. The impact of organization size

Previous research has shown that organization size is one of the key variables in an organization’s context that impacts innovations of all types (Damanpour, 1992). The findings of this study further reiterated its importance particularly with respect to method of sourcing. Large organizations were more likely to internally source all types of innovations. This can be attributed to the following reasons: (a) large organizations have access to a larger pool of resources and a more diverse knowledge base (Nord and Tucker, 1987; Damanpour, 1992), (b) large organizations tend to be older and have a rich and varied experience base (Mintzberg, 1979), and (c) larger organizations also tend to have more established processes for settling conflict and coordinating the various activities, as compared to smaller organizations. The combined availability of resources, experience, knowledge and structural coordination enable large organizations to successfully internally source innovations.

5.5. The impact of product–process innovation types

This study found that the distinction between product and process innovations was critically important in explaining all the three dependent variables associated with the adoption process. We found that process innovations were more likely to be internally sourced, more costly to implement and also perceived as more effective. An earlier study found that process innovations were more tacit, more systemic and more complex than product
innovations (Gopalakrishnan et al., 1999). This lends further support to our theory that the knowledge-based typology should be used in conjunction with existing typologies of innovation, and there are some identifiable differences in the dependent variables based on the three knowledge-based variables.

5.6. Generalizability of findings and future research

Commercial banking is different than many other industries: few resources are allocated to R&D; firms are quick to copy each other; the major investments are continually tinkered with and refined to maximize the return on investment. In general, they take a less research-intensive approach to organizational learning. In other words, most firms in the banking industry follow the generic knowledge strategy described as “Exploitors” by Bierly and Chakrabarti (1996b); they focus more on further exploiting existing technologies than developing radical breakthrough technologies. However, competition has increased dramatically in the last decade after deregulation of the industry and banks have recently placed an increased emphasis on innovation in an attempt to remain competitive. Elements of banks’ knowledge strategies, such as the practice of outsourcing the development of many innovations, have become institutionalized throughout the industry and are a result of the industry’s unique history. The findings of this study provide some preliminary pointers about the types of decisions to keep in-house and the types to outsource.

We identify three key limitations of this study. First, we considered innovations that were successful and survived over time rather than innovation failures. Since we had a wide variety in bank types and bank size in our sample and we wanted to maximize innovation adoption data available, we felt that this was necessary. Innovation failures by pioneers, of course, were not adopted by imitators and, thus, did not apply to most firms. This somewhat limits the generalizability of this study. Second, we used single item measures to capture the key constructs of method of sourcing, cost of implementation and effectiveness. These, probably were limited operationalizations of the constructs. Finally, our regression models explain a very small percentage of the overall variance in the dependent variables. However, this should be seen as an exploratory study where more work needs to be done to increase the reliability of this study’s preliminary findings.

This leads us to the question of how generalizable to other industries are the findings of this study? Of course, this question cannot be conclusively answered until more studies are conducted in other industries. However, we feel the results are generalizable mainly because, for the most part, they support our theoretically-developed hypotheses. Clearly, the ideas in this exploratory study need to be further refined and applied in different research settings.

This study offers several interesting avenues for future research. We outline three specific areas here. First, studies in the future could explore non-linear relationships between these and other knowledge dimensions and innovation adoption parameters. Second, further analysis could be done comparing the impact of organization-related factors like structure, culture, and innovation factors on innovation adoption. It could be that some innovation-related factors interact with certain organization-related factors. Finally, studies should be conducted in manufacturing and other service industries to evaluate the robustness of these results.
Appendix A. List of innovations used in the study

1. ATMs (on bank premises)
2. ATMs linked to statewide networks
3. Debit cards
4. Automated mortgage generation
5. Credit cards
6. NOW/super NOW accounts
7. Zero balance disbursement account
8. Sweep (asset management) account
9. Self directed IRA account
10. Linked certificates of deposit
11. Money market deposit
12. Adjustable rate mortgage
13. Mortgage equity account
14. Discount brokerage service
15. Mutual funds
16. Computerized loan document generation
17. On-line teller terminals
18. Derivatives (swaps, options futures/forwards)
19. Lobby automation (video banking)
20. Direct payroll deposit
21. Automated voice response systems
22. Loan tracking system (retail)
23. Risk management systems (tracking a bank’s financial exposure)
24. Lock box
25. Personal banker
26. Customer information file
27. Treasurer work station
28. High-speed image processing of checks
29. High-speed image processing of office documents
30. Automated check reconciliation systems
31. Truncation of the check handling process

Appendix B. Expert questionnaire to categorize innovations

EVALUATION OF INNOVATIONS

After extensive research of the banking literature index between 1982 and 1992, 31 programs have been identified as innovations based on the fact that they were either implemented by the banking industry for the first time, or, became popular, during this time period. Starting on page 3 we have listed these 31 innovations, we would like you to answer the following 7 questions about each innovation.
The first two questions are about whether the knowledge contained to implement the innovation is tacit or explicit. Questions 3–5 pertain to whether the development of the innovation is closely tied into other parts of the organization. Questions 6–7 attempts to evaluate the simplicity or complexity of the innovation.

The questions need to be answered on a five point scale

<table>
<thead>
<tr>
<th>Very high</th>
<th>high</th>
<th>medium</th>
<th>low</th>
<th>very low</th>
</tr>
</thead>
<tbody>
<tr>
<td>5----------</td>
<td>4-----</td>
<td>3------</td>
<td>2----</td>
<td>1--------</td>
</tr>
</tbody>
</table>

**Tacit versus Explicit**

1. To what extent do manuals and documents accurately explain the implementation and operation of this innovation?
2. To what extent is educating and training personnel for this innovation a quick and easy job?

**Systemic versus Autonomous**

3. To what extent is the innovation independent of other products and services offered by the organization?
4. To what extent do users of the innovation need to be in contact with other departments within the organization to implement it effectively?
5. To what extent is knowledge about other systems within the organization necessary to implement this innovation effectively?

**Simple versus Complex**

6. To what extent is this innovation intellectually sophisticated or difficult to implement?
7. To what extent is this innovation original or new?

**References**


