Distinguishing Between Knowledge Transfer and Technology Transfer Activities: The Role of Key Organizational Factors

Shanthi Gopalakrishnan and Michael D. Santoro

***Abstract*—Knowledge transfer and technology transfer are often used interchangeably and while both knowledge transfer and technology transfer are highly interactive activities, they serve different purposes. Knowledge transfer implies a broader, more inclusive construct that is directed more toward understanding the "whys" for change. In contrast, technology transfer is a narrower and more targeted construct that usually embodies certain tools for changing the environment.**

Grounding our work in the 7-S framework, we examine the role of key organizational factors in facilitating knowledge transfer and technology transfer activities. Survey data for this study were collected from 189 industrial firms representing 21 different industrial sectors. Results show that there are differences in the types of firm structures, cultures and university policies for intellectual property rights (IPR), patent ownership, and licensing that facilitated knowledge transfer activities compared to those that facilitated technology transfer activities. Specifically, firms with more mechanistic structures and more stable direction-oriented cultures were associated with higher levels of knowledge transfer. Conversely, firms with more organic structures, more flexible change-oriented cultures, and more customized university policies for IPR, patent ownership, and licensing were associated with higher levels of technology transfer. The firm's trust in its university research center partner was equally important for both activities. We conclude by discussing the implications of our findings for future research and management practice.

***Index Terms*—Industry–university relationships, knowledge transfer, organizational context, technology transfer.**

I. Introduction

EVER-SHORTENING product life cycles and accelerating rates of technological change have created greater needs to effectively transfer technology and knowledge across organizational boundaries [28], [32]. Interorganizational initiatives such as strategic alliances and joint ventures are powerful alternatives to organizations undertaking projects alone because they enable organizations to share risks, build on jointly shared capabilities, and create synergies for better competitiveness [11]. Of particular interest in this study are interorganizational initiatives between industrial firms and universities since there has been a recent proliferation of alliances between industrial firms and universities [57] because they allow for the sharing of personnel, technologies, and knowledge [36], [37]. As a result, industry/university (I/U) alliances create sophisticated knowledge pools along with highly trained people that can help propel knowledge creation and the development and commercialization of valuable new technologies [4].

Some researchers use the terms "technology transfer" and "knowledge transfer" interchangeably, e.g., [29] arguing that the creation of new knowledge involves the understanding and absorption of certain new technologies. Others contend that the interorganizational interpersonal relationships that enable technology transfer eventually create new knowledge [41]. We follow more along the lines of those that contend technology transfer is a much narrower construct than knowledge transfer [2], [10]. For example, *technology* refers more to new tools, methodologies, processes, and products [59] and, as such, is primarily an instrument used for changing the environment [58]. *Knowledge*, on the other hand, embodies broader learning evidenced as changes in the strategic thinking, culture, and problem-solving techniques used by a firm [23].

We go beyond the current literature in this paper and attempt to clarify this debate by presenting a framework illuminating differences between technology transfer and knowledge transfer and then we explore whether differences between these two activities can be empirically demonstrated. We also extend the work done by Santoro and Gopalakrishnan [49], where they identified certain organizational factors that facilitated knowledge transfer. Here, we investigate whether different types of organizational structures and processes affect technology transfer and knowledge transfer activities differently. Our basis for focusing on organizational structure and process factors is grounded using the 7-S framework [42].

Using the 7-S framework as our basis for selecting certain organizational characteristics, the research question for this study is: Do the industrial firm's structure and certain characteristics and processes, i.e., culture, trust, and university policies for intellectual property rights (IPR), patent ownership, and licensing, facilitate knowledge transfer and technology transfer activities differently?

In addressing our research question, we first discuss the differences between knowledge transfer and technology transfer. We then describe the relationships that we expect to see between each of the organizational factors mentioned and knowledge transfer and technology transfer activities. Our proposed hypotheses are tested using survey questionnaire data obtained from 189 industrial firms collaborating with 21 prominent university research centers located within the United States. We conclude this paper by discussing our findings and providing implications for both research and practice.

Manuscript received October 20, 2001; revised April 7, 2003. Review of this manuscript was arranged by Editor-in-Chief G. F. Farris.

S. Gopalakrishnan is with the School of Management, New Jersey Institute of Technology, Newark, NJ 07102 USA (e-mail:gopalakr@adm.njit.edu).

M. D. Santoro is with the College of Business and Economics, Lehigh University, Bethlehem, PA 18015 USA (e-mail:mds8@lehigh.edu).

Digital Object Identifier 10.1109/TEM.2003.822461

II. Conceptual Framework and Hypotheses

The conceptual framework for this paper is built around two key notions. First, knowledge and technology are distinct constructs such that each type of transfer entails different kinds of activities, is often undertaken by different personnel within the organization, and involves different kinds of interactions and procedures [2], [5]. Second, while knowledge transfer and technology transfer are different, both are important value-creating activities that occur over time and within the rubric of certain organizational factors that are related to and important for interorganizational collaboration [49]. Within the context of I/U relationships, certain factors in both the industrial firm and the university may be consequential. To narrow the scope of this study, we concentrate on factors related only to the industrial firm since the National Science Foundation (NSF) and others have already focused much attention on the university, (see, for example, [4], [6], [36], and [37]) leaving the industrial firm side of these relationships less studied.

Factors in the external and internal context of the firm affect knowledge transfer and technology transfer activities. For example, the firm's external context can include broad aspects such as the prevailing conditions in a country that affect technological collaboration between universities and firms [55], [64], while the immediate external context includes factors such as policies within the firm and the partnering university that can either stimulate or inhibit the exchange of knowledge and technology [20], [65]. The firm's internal context embodies only the internal environment within the firm's boundaries where transferred technology and knowledge are used [29], [32], [49]. Since both the external and internal contexts are crucial to effective knowledge transfer and technology transfer, the 7-S framework [42] was used to parse out the key components of the industrial firm's context. We build on the idea that appropriate conditions in the firm's context can facilitate knowledge transfer and technology transfer while the lack of appropriate conditions can deter and inhibit these processes [21].

A. *Knowledge Transfer Versus Technology Transfer*

The literature suggests that the relationship between knowledge and technology is both complex and subject to much interpretation. Technology and knowledge can be so intertwined that any mention of one implies the other. For example, some contend that technology is a form of knowledge [16] since technology not only consists of machines and mechanical equipment but also comprises technical knowledge and participant skills [51]. This confluence in knowledge and technology leads some to think of knowledge transfer and technology transfer as interchangeable.

We argue against this notion. While clearly linked, knowledge and technology are distinct constructs embodying different activities. At its simplest, technology is more about knowing how things are done while knowledge is more about knowing why things occur. Thus, knowledge is more about "why" and includes more elements of human judgment, more handling of exceptions, and, hence, tends to be less codifiable, and more tacit than technology [5]. According to Nonaka [40], knowledge involves cognitive structures that represent a given reality. Managers tend to associate knowledge with specific situations [61] and, therefore, knowledge is in the eye of the beholder and takes on conceptual meaning by its application. In contrast, technology tends to be more specific in its focus, more tangible, and less prone to subjective interpretation. To help clarify the distinction between these two constructs, Table I contrasts the concepts of technology and knowledge on a number of key dimensions.

At the core of our argument, we suggest that while technology is derived from certain types of knowledge, technology is more a tool, or a set of tool systems for transforming the environment [59]. Following Thompson's [58] notion of technical rationality, technology is an instrument that is evaluated on its ability to produce desired outcomes in an economical fashion. As an instrument for achieving economic outcomes, technology is usually more explicit and codified. As such, information about a certain technology tends to be stored in blueprints, empirical equations, and other formal documents such as operating manuals. Examples of technology include production processes and computer hardware.

Knowledge is much broader than a particular technology. Knowledge includes scientific, mathematical, physical, and social/behavioral theories and principles [59], some of which is not currently put to use or readily quantifiable [58]. Moreover, knowledge captures the underlying cause and effect relationships on which a technology is constructed and embedded [58] and accommodates exceptions, adaptations, and unforeseen events [17]. Thus, the ability to control temperatures and pressures to align grains of silicon and form silicon steel is an example of technology while the understanding of the underlying chemical and physical process that produces the alignment is an example of knowledge. Knowledge includes the know-how necessary for commercializing and managing a product or process while the actual product or process represents a technology. The know-how necessary for commercialization serves to further develop a firm's absorptive capacity that is key for technology assimilation [8].

Technology management plays a more important role in the post-competitive phase of technological development as ideas and inventions are brought to market as commercialized technologies. This technology-pull driven science serves to create a new body of knowledge that provides the springboard for further technological advances [5]. In contrast, knowledge has greater elements of tacitness than technology. As a result, knowledge management plays an important role in both the precompetitive phase of technological development due to the close link to the new frontiers of basic science [2] and in the postcompetitive phase as knowledge and technologies are assimilated into the organization [8].

A large literature suggests that both technology and knowledge can move across organizational boundaries and be transferred between universities and firms, e.g., [4], [36], [37]. Following our previous discussion that there are differences between knowledge transfer activities and technology transfer activities, we address the need to empirically examine whether organizational context affects these two activities differently.

TABLE I
KEY DIMENSIONS OF TECHNOLOGY AND KNOWLEDGE TRANSFER

Dimensions	Technology	Knowledge
Breadth of construct	Narrower and more specific construct. Technology can be seen as an instrumentality or set of tools for changing the environment	Broader and more inclusive construct. Knowledge embodies underlying theories and principles related to cause and effect relationships
Observability	More tangible and precise	Less tangible and more amorphous
Overarching Characteristic	More explicit and codified where learning can be taught and information is stored more in blueprints, data bases, and manuals	More tacit where learning is by doing and information is stored more in people's heads
Management Phase(s) of most consequence	Post-competitive phase of technological development (Integral for the commercialization of ideas and inventions)	Pre- and Post competitive phases of technological development
Organizational Learning	More reliance on controlled experiments, simulations, and pilot-tests	More trial and error, wider use of gestalts
Nature of Interactions	Inter- and intra-organizational interactions that deal most with operational issues and how things work	Inter- and intra-organizational interactions that deal most with strategic issues and why things work the way they do

B. Role of Organizational Context in Knowledge Transfer and Technology Transfer Activities

Effective knowledge and technology creation, development, and transfer depend on an enabling context. An enabling context, according to Nonaka [40], is built around the Japanese idea of ba (or "place") and such an organizational context can be physical, virtual, or mental—or more likely all three [61]. This definition of context emanates from the fact that knowledge is dynamic, relational, and based on human interaction. For example, the type of structure an organization has influences the extent to which an organization interacts with its external environment to identify and acquire appropriate knowledge and technologies.

Oliver and Liebeskind [41] reinforce the idea that technology transfer takes place because of the interaction of scientists, technology transfer personnel, and managers all within the rubric of each organization's rules and policies. The interaction among these people, whether it is face-to-face, or virtual, over time creates communities of practice that amplify and develop new information through the sharing of knowledge [40]. These "communities of practice" tend to develop their own rituals, practices, norms, and values [61]. It follows that elements of the physical context and relational context can impact the activities that occur when universities and industrial firms interact.

Santoro and Gopalakrishnan [49] established that organization structure, trust, and an organization's culture are all significantly associated with knowledge transfer activities. We extend this work further and explore whether organizational context plays a different role in knowledge transfer and technology transfer activities. In this study, we are not investigating the actual transfer of knowledge or technology from the university research center to the industrial firm. Rather, we are focusing on knowledge and technology transfer processes and infrastructures that facilitate transfer activities.

As Santoro and Gopalakrishnan [49] showed, identifying factors in an organization's context is a key issue. The 7-S framework [42] proves useful by illuminating the following seven key elements for consideration:

1) strategy;
2) structure;
3) shared values;
4) support systems;
5) style;
6) skills;
7) staff.

In this study, we build on the first five of the 7-S framework—strategy, structure, shared values, style, and support systems. While the remaining two—skills and staff—are also potentially valuable elements, these factors are at a more microlevel of analysis and, therefore, are beyond the scope of this investigation. Since our primary focus in this study of I/U relationships is on the industrial firm, *strategy* refers to the actions that firms pursue in order to improve their overall competitive position and in this case the strategy is the firm's pursuit of knowledge transfer and/or technology transfer. *Structure* refers to the industrial firm's organizational structure. *Shared values* are the foundations around which the business is built as represented by the firm's culture [50]. Regarding *style*, the firm's trust of its university partner is a key manifestation of the firm's *style* since in I/U relationships this trust is often a result of certain joint activities and the firm's symbolic behavior [42]. Finally, *support systems* are represented by the university's policies for IPR, patent ownership, and licensing. We include this factor as a support system since university policies for IPR, patent ownership, and licensing are often a key stimulant as devised by university administrators that industrial firm members can use to build support for collaborating with universities [6], [45]. We describe each of these important components and their linkage to technology and knowledge transfer activities in Sections II-C–G.

C. Organizational Structure

An industrial firm's structure influences the firm's processes and activities [51]. Knowledge and technology transfer involve identifying appropriate external sources, interacting with those external sources, acquiring the knowledge and technology, and integrating them into existing organizational systems and procedures [65]. A widely used schema for understanding organization structure was put forth by Burns and Stalker [7]. Following Burns and Stalker [7], an organization's structure can be classified on three dimensions: 1) number of hierarchical levels; 2) extent to which knowledge and control are concentrated at the top of the organization (centralization); and 3) the degree to which rules and policies are adhered to (formalization). Burns and Stalker [7] suggested that the configuration of these three dimensions determined whether an organization's structure tended to be mechanistic or organic.[1]

To explain the relationships between a firm's structure and its ability to transfer knowledge and technology we extend Daft's dual core model [12]. The dual core model was originally conceived to explain the relationship between structure and technical and administrative innovations. Daft [12] theorized that new technologies or technical innovations follow a bottom up process originating in the technical core and then percolating up to higher levels of the organization. In contrast, administrative innovations originate in the administrative core, i.e., at higher levels of the organization, and flow down to lower levels through a top-down process.

Following our earlier discussion, technology transfer incorporates more specific technical knowledge and, therefore, resembles Daft's [12] notion of technical innovations. Technology transfer happens through a dense network of individual ties between university scientists and engineers and firm R&D personnel that in turn can create a "community of practice." [40], [41]. The ability to transfer technology to, and within, the firm depends on the firm's ability to accurately understand, interpret, evaluate, and absorb a technology. This is best accomplished by the firm's engineers and technical personnel since they often best understand the language used by university scientists and researchers [20]. Since technology transfer activities revolve around how things get done, personnel in the technical core must often provide direction to those in higher levels of the organization. This type of bottom-up interaction suggests that a more organic, i.e., decentralized, informal, and flatter structure, would better facilitate the activities associated with the technology transfer process.

In contrast to the technology transfer process discussed earlier, we contend that knowledge transfer is more aligned with Daft's [12] notion of administrative innovations because it deals with more of the firm's overall conceptual vision and "why" initiatives should be pursued. Effective knowledge transfer requires greater top management involvement to ensure that the underlying "why" from top management's perspective is communicated effectively to the firm's university partner. Top management's involvement is also needed to disseminate the "why" to the technical core, i.e., to those in the organization that know how to get things done [58]. Top-down interactions throughout the organization related to translating and interpreting "whys" into "hows" demand clear reporting relationships, greater formalization, and increased centralization to ensure predictability, efficiency, and coordination. More mechanistic structures aid the development of procedures for the translation, interpretation, assimilation, and the institutionalization of activities associated with knowledge transfer [49]. We, therefore, propose the following hypothesis:

H1: Mechanistic structures are more associated with knowledge transfer activities than with technology transfer activities.

D. Organization Culture—An Indicator of Shared Values

Organizational culture is a complex construct consisting of many concepts, most notable among them, shared values [3], [50] and shared meanings [14], [34]. Culture is important since it influences the actions of organizational members by imposing a repertoire of habits and values [22]. According to Peters and Waterman [42] shared values embody the broad notions of direction that top managers want to infuse into the organization. As such, organizational culture represents the third "S" in the 7-S framework, i.e., shared values.

Smircich [53] suggests that from a functionalist perspective organizational culture is an organizational variable; culture is inherent to every organization. Denison and Mishra [15] elaborate this idea further by identifying four cultural traits that represent a firm's culture within the functionalist view. Denison and Mishra's [15] four cultural traits are involvement, adaptability, consistency, and sense of mission. Involvement refers to organizational members' sense of ownership, responsibility, and commitment to the organization's growth and survival.

[1]Although Burns and Stalker's [7] typology is four decades old, as a continuum measure, it is still relevant in helping to depict major organizational structural characteristics where mechanistic structures are associated with more hierarchical levels and higher degrees of centralization and formalization while organic structures are associated with less hierarchical levels and lower degrees of centralization and formalization.

Adaptability is the organization's capacity for internal change in response to external conditions and its openness to ideas from outside the firm. Consistency reflects the level of member conformity to the firm's collective behaviors and systems while a sense of mission provides organizational members with clear purpose and meaning. Following Denison and Mishra [15], firms scoring high on involvement and adaptability are seen to have flexible and change-oriented cultures while firms scoring high in consistency and sense-of-mission are classified as having stable and direction-oriented cultures.

While Denison and Mishra's [15] work specifically related these four cultural traits to firm performance (i.e., sales growth, profits, quality, and employee satisfaction), their traits are similar to those identified by Maidique and Hayes [33], which have been shown to be important for firms obtaining external technology and knowledge. For example, a strong sense of involvement and adaptability provides organizational members with the motivation to be proactive in staying abreast of new technology streams related to the latest technological developments. As discussed earlier, technology transfer activities involve the technical core and this process works better when technical personnel are empowered and heavily involved within the organization. An earlier study has shown that when R&D personnel are involved in the technology acquisition process, the start-up phases of technology acquisition including the evaluation and preparation stages, are accomplished very smoothly [52]. Since technology focuses more on the 'how', heavy involvement also improves the organizational members' ability to receive and adapt new technologies while reducing the inhibitions caused by the "not-invented-here" syndrome [27]. Moreover, technology transfer activities generally tend to be more specific and explicit than knowledge transfer. As a result, technology transfer works better when empowered personnel in the firm, who understand the language of their university counter-parts, interact directly with them. Flexible change-oriented cultures characterized by high member involvement and adaptability should, therefore, facilitate the process. In contrast, since knowledge transfer involves more amorphous concepts centered on strategic issues related to "why" it may not be as well served by flexible, change-oriented cultures. Thus:

H2(a): Flexible, change-oriented cultures are associated more with technology transfer activities than with knowledge transfer activities.

Knowledge tends to be more tacit and amorphous when compared to technologies that are transferred. Consistency provides unanimity of beliefs and reduces conflict about the presumed course of action. Moreover, an organization's sense of mission provides organizational members with a sense of meaning and overall direction [25] crucial for rallying around and supporting more visionary concepts that are often the basis for knowledge acquisition activities. Since knowledge is often more amorphous, top management needs to take a more active role in communicating to organizational personnel how knowledge will eventually be used within the organization. Following a top-down approach, this is better facilitated by a stable direction-oriented culture [12]. Moreover, organizational members in firms with more stable direction-oriented cultures are more likely to accept top management intervention in the knowledge transfer process since receiving overall direction from above is an instilled way of doing business [50]. We propose the following:

H2(b): Stable, direction-oriented cultures are associated more with knowledge transfer activities than with technology transfer activities.

E. A Firm's Trust of Its University Partner—An Indicator of Style

Levinson and Minoru [29] argue that trust is cultivated between organizations through personal relationships, and, that informal interactions built on the trust of external individuals and organizations are crucial for interorganizational learning. We extend this notion and discuss the extent to which organizational trust plays a role in knowledge transfer and technology transfer activities.

Trust is the "willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" [35, p. 712]. In other words, two parties collaborate to pursue mutually compatible interests rather than to act opportunistically [13], [62]. Since our focus in this study is centered on the industrial firm and its trust of external organizations, we concentrate on the firm's trust of its university partner and the role this plays in knowledge and technology transfer activities.[2]

Some organizations are more likely to trust other organizations because of their organizational history and culture. Rotter [48] suggests that trust can result from a generalized expectation of others. A firm's propensity to trust its university partner may also be a shared value because of the firm's strategic intent [25] such that the firm believes that interorganizational synergies from collaborative ventures may be better leveraged and exploited through trustworthy partnerships. The firm's trust is based on its belief that its university partner has needed expertise and is willing to share its expertise to help the firm achieve its objectives [45]. Two key issues surface with respect to trust within this context: 1) How does trust relate to knowledge transfer activities and technology transfer activities? (2) Is trust equally important for each of these two different transfer processes? We explore these two issues in the following section.

The industrial firm is especially vulnerable in interorganizational relationships since the firm exposes its unique resources to its university partner. Opportunistic behavior by the university partner can cause the firm to lose some of its key competitive advantages. We offer two reasons to illuminate how trust reduces this vulnerability and facilitates technology transfer and knowledge transfer activities. First, when collaborating organizations build trust, they develop confidence about their partner's abilities and expected behavior [13]. Trust also serves as a control mechanism that helps govern economic transactions between the firm and its university partner [31]. When a high level of trust exists, the firm has more confidence in the university

[2]We recognize that trust is a dyadic phenomenon. However, we focus here on only this one-way aspect of trust since we are interested in what's important to the industrial firm

research center's abilities and motives and is more willing to share its ideas, feelings, and goals with the center [31], [35]. Following Lewicki and Bunker's [30] notion of knowledge-based trust, the firm's knowledge about the university research center makes the research center's expected behavior more predictable.

Although a large body of trust literature implies that trust is generally important for most interorganizational activities including the transfer of both knowledge and technology, e.g., [13], [29], [35], we argue that trust is more important for the transfer of knowledge, particularly tacit knowledge. Tacit knowledge is less tangible and more ambiguous than explicit knowledge [23]. Transferring tacit knowledge requires a high level of interpersonal interactions among individuals in the firm and their university partners. The firm's trust of its university research center partner creates a more open climate within the firm that allows for a freer transfer of ideas, especially those that are more abstract, which is crucial for activities associated with tacit knowledge exchange [23]. Technology, on the other hand, is more codified and can, therefore, be transferred to a large extent through software, blueprints, and written documents. Since technology transfer can be accomplished with less direct personal communication and human interaction than knowledge transfer, the firm's trust of its university partner may not be as critical. Following this reasoning we propose the following hypothesis:

H3: The industrial firm's trust of the university research center is more strongly associated with knowledge transfer activities than with technology transfer activities.

F. University Policies for IPR, Patent Ownership and Licensing—A Key Support System

IPRs, patent ownership, and licensing agreements are a major consideration in I/U collaborative ventures [45]. Since universities and industrial firms both use IPRs, patents, and licenses as a way to increase revenues, establish competitive advantage, and enhance organizational recognition, competition over these rights is often contentious [44].

If universities want to encourage and stimulate more relationships to facilitate technology transfer with industry, then universities must be willing to tailor IP agreements in order to better meet industry's needs [6]. Some of the more creative university research centers have attracted larger numbers of industrial firm partners by delaying the publication of research results in academic journals, allowing an industrial firm to equally share royalties, and providing first option exclusive licensing rights to a sponsoring industrial firm [19], [44]. Policies such as these have several key advantages. First, when universities move away from sole retention of IPRs, patent ownership and licensing, industrial firms see the university as a flexible and motivated partner. Second, by offering industrial firms meaningful incentives the university demonstrates to the industrial community that industry alliances are valued [6]. Finally, when universities develop customized IPRs, patent ownership, and licensing rights that meet industry's specific needs, firms are more likely to commit even more time and resources to their university partnerships in order to bring new technologies to market [19]. Together, these benefits provide an integral support system for facilitating I/U relationships.

While customized university policies for IPR, patent ownership, and licensing facilitate I/U relationships, these policies have an even greater impact on technology transfer since here the more explicit and more codified constructs are more readily employed for the commercialization of patented and licensed new products and processes. In contrast, knowledge transfer often consists of tacit, nonpatented and nonprotected know-how in both the pre-and postcompetitive phases of a new product or process. The value, therefore, from a specific knowledge base is difficult to protect through IPRs and patents because this inherently tacit knowledge base usually requires specific and specialized skills from the personnel that work with it. Consequently, policies related to IPR, patent ownership, and licensing are less meaningful for knowledge transfer than for technology transfer. Therefore:

H4: Customized university policies for IPRs, patent ownership, and licensing have a stronger association with technology transfer than with knowledge transfer activities.

G. Control Variable—Industrial Firm Size

Besides the five independent variables that were described in Sections II-A–F, we included the size of the industrial firm as a control variable. We include firm size since there are different views on the role of size in knowledge transfer and technology transfer activities. Some contend that larger organizations are more able to acquire and integrate external technology and knowledge due to greater slack resources [39], [46]. Moreover, the larger the firm, the greater its participation in a wider array of external relationships [37], and the greater its absorptive capacity [8], [29]. On the other hand, smaller organizations can be more nimble and more flexible than their larger-sized counterparts enabling smaller firms to quickly deploy expertise and technologies as external conditions dictate [1], [7]. By including firm size as a control variable in this study, we hope to better understand the impact firm size may have on knowledge transfer and technology transfer activities.

III. Method

A. Overall Research Approach

In this study, knowledge transfer and technology transfer activities were examined within the context of I/U relationships. While I/U relationships can manifest themselves in many ways, e.g., consulting arrangements with individual faculty or contract research, we concentrated on industrial firms' relationships with university research centers. University research centers including the NSF supported Engineering Research Centers (ERCs) and Industry–University Cooperative Research Centers (IUCRC's) were our major focal point. University research centers such as these have an explicit mission to work with industry to advance knowledge and new technologies through an array of relationship alternatives that facilitate this mission [4], [38]. To better understand the dynamics of I/U relationships within this venue, two different sources of exploratory data were initially obtained. First, an analysis of 12 recent NSF program evaluations and survey protocols were examined. Next, 15 semistructured, face-to-face and phone interviews were conducted with industrial firm representatives and university center directors.

Both sources of exploratory data were used to clarify and substantiate our conceptual framework. The semistructured interviews also provided face validity to the survey questionnaire that was used for obtaining primary data for hypotheses testing.

In order to obtain a sample of industrial firms working with university research centers, a variety of research centers in prominent public and private U.S. universities were contacted. Twenty-nine university research centers were originally contacted. These 29 centers were a random sample of ERCs, IUCRCs, and non-NSF supported university research centers selected from an overall list of 36 such centers. Thus, the 29 centers originally contacted represented 80% of the total sample. Twenty-one centers of the 29 agreed to participate in this study. Those centers opting not to participate declined due to time and resource constraints. The 21 participating university research centers provided complete lists of their corporate partners, including the names, addresses, and phone numbers of all members in the firm working with the research center. A survey questionnaire was then mailed to each industrial firm representative identified.

B. Sample

The 21 university research centers that provided lists of their corporate sponsors consisted of eight NSF supported ERCs, eight NSF supported IUCRCs, and five research centers outside these models. The 21 participating centers represented a diverse, cross-section of disciplines with a wide variety of member companies. On average, each university research center in our sample set works with 20 industrial firms. In total, the 21 participating centers collaborate with 421 industrial firms. Survey questionnaires were sent to all 421 firms. Of these, 207 survey questionnaires were returned, but five were missing significant amounts of data. Thus, 202 responses were useable for a response rate of 48%. An analysis of the respondent firms compared with the nonrespondent firms showed no significant differences based on firm size, industry, partnering university research center, or length of relationship.

Our respondents were senior-level members of their firms, e.g., Owners/Presidents, VPs/Directors of R&D, Directors of Technology, or Project Managers. Each of the respondents was thoroughly knowledgeable about the I/U relationship, actively involved in the relationship, and each had a significant stake in the collaborative venture. Five of the participating firms had more than one person involved in their I/U relationships. Here, survey questionnaires were sent to each participant within the firm. In the case of multiple responses from a firm, the responses were aggregated into one score to reflect the firm's collective insight on its relationship with the university center [47]. The participants in each firm were homogeneous to the extent that formal I/U relationship objectives existed in each firm. Homogeneity was confirmed by high inter-rater reliability (Spearman-Brown formula = 0.74 mean individual and 0.85 mean aggregate reliability for two participants, and 0.71 mean individual and 0.89 mean aggregate reliability for three participants). As a result of this data aggregation, the original 202 responses were reduced to 189. This aggregated sample of 189 was then used in our analyses.

The majority of participating firms were large; 125 firms or 66% had at least 500 employees while 64 of the firms or 34% had fewer than 500 employees.[3] Some of the large firms had as few as 500 employees while a number of these firms had several hundred thousand employees. Some of the small firms had as few as five employees while a number of these firms fell just below the employee threshold of 499. Regarding industry representation, two-digit standard industry classification codes were used [37] and showed that 21 industries were represented. The largest concentrations came from the following industries: industrial/commercial machinery (30 firms); microelectronics and computers (27 firms); chemical or allied products (20 firms); and primary metals or fabrication (17 firms). The smallest concentrations came from the following industries: paper or allied products (3 firms); food or kindred products (3 firms); military unit (4 firms); and agriculture (4 firms).

C. Measures

The measures in this study were adapted from the existing literature and based on input received in our exploratory interviews, modifications were made to some of the items to properly capture this study's specific constructs. All measures were seven-point Likert-type scales, except for firm size and all were multiple item scales, except for firm size, and university policies for IPR, patent ownership, and licensing. The alpha coefficients for the multi-item measures and the references to the literature from which all these measures were adapted are noted below.

1) Knowledge Transfer Activities: Our first dependent variable was measured by an eight-item scale (alpha = 0.91). Since strategy refers to the actions firms engage in to create competitive advantage, these eight items concentrate on interpersonal activities that the firm engaged in with the university research center to understand, leverage, and exploit underlying principles in the *pre-and post-competitive phases of technological advancement*. Relying on the NSF's typology of I/U collaboration [38] and our own exploratory interviews conducted at the outset of this research, 19 items were initially used to measure a broad array of I/U relationship activities. Using principal components extraction, one factor (knowledge transfer activities) with an Eigenvalue of 8.13 was extracted from this initial set of nineteen items. The resulting factor was then used in our analyses as one of our dependent variables.

Table II provides results from the VARIMAX rotation, where 0.5 was used as the loading threshold [24]. Based on these, knowledge transfer included the following activities:

a) firm's involvement in curriculum development;
b) number of student interns hired by the firm;
c) firm's involvement in the development and use of cooperative education programs;
d) level of participation in jointly owned operated facllities specifically for developing and commercializing new technologies.
e) level of participation in university research center sponsored consortia;

[3]The SBA classification was used to define large versus small firms; large firms are those with 500 employees and more while small firms are those with less than 500 employees.

TABLE II
FACTOR LOADINGS FOR THE KNOWLEDGE TRANSFER AND TECHNOLOGY TRANSFER ACTIVITIES MEASURES

Knowledge Transfer Activities	Loadings
Firm's involvement in curriculum development	.81
Student interns hired by firm from formal arrangements between firm and university center	.78
Firm's involvement in developing and using cooperative education programs	.77
Recent university graduates hired by firm as a direct result of I/U relationships	.75
Level of participation in university research center sponsored consortia	.71
Level of participation in university research center sponsored trade associations	.58
Level of participation in co-authoring research papers with university center researchers	.52
Number of personnel exchanges with university center specifically for transferring knowledge	.52
Technology Transfer Activities	**Loadings**
Time spent interacting with center personnel for developing & commercializing new technologies	.83
Level of joint decision-making in technological consulting arrangements for developing and commercializing new technologies	.79
Level of joint decision-making in developing & commercializing new technologies	.74
Number of personnel exchanges specifically for developing & commercializing new technologies	.69
Level of participation in research center extension services specifically for developing & commercializing new technologies	.58

f) level of participation in university center sponsored trade associations;
g) level of participation in coauthoring research papers with university center researchers;
h) number of personnel exchanges with the university research center specifically for transferring knowledge.

2) Technology Transfer Activities: Our second dependent variable was also extracted through principal components factor analysis (with an Eigenvalue of 4.5) and was measured by a five-item scale (alpha = 0.92). Again, since strategy refers to the actions firms engage in to create competitive advantage, these five items concentrate on interpersonal activities that the firm engaged in with the university research center to understand, leverage, and exploit underlying principles related to the *post-competitive phase of technological advancement*. This factor, also detailed in Table II, embodies the following five activities:

a) time spent interacting with university research center personnel specifically for developing and commercializing new technologies;
b) level of joint decision making in technological consulting arrangements for developing and commercializing new technologies;
c) level of joint decision making in developing and commercializing new technologies;
d) number of personnel exchanges specifically for developing and commercializing new technologies;
e) level of participation in research center extension services specifically for developing and commercializing new technologies.

3) Organization Structure: This variable was measured by a three-item scale (alpha = 0.75). Following Burns and Stalker [7], organization structure was represented by number of hierarchical levels within the firm, the extent to which members follow directives (extent of centralization), and the extent to which the firm has rigid rules and policies (extent of formalization). On a continuum, firms scoring higher on hierarchical levels, extent of centralization, and extent of formalization were more mechanistic while those scoring lower on these three dimensions were more organic.

4) Stable and Direction-Oriented Culture: Following Denison and Mishra [15] a four-item scale (alpha = 0.84) was used to represent the strength of the firm's consistency and sense of mission that are the two elements of a stable and direction-oriented culture. The following were the four items measured:

a) firm's consistency and predictability in their approach to doing business;
b) extent of member agreement regarding the way in which things are done;
c) extent to which the firm has a long-term purpose and clear direction for the future;
d) extent to which firm members have a shared vision regarding what the organization will be like in the future.

5) Flexible and Change-Oriented Culture: Following Denison and Mishra [15] a four-item scale (alpha = 0.78) was used to represent the strength of the firm's involvement and adaptability that are the two elements of a flexible and change-oriented culture. The following were the four items measured:

a) extent of member participation in decisions;
b) extent of member cooperation and collaboration across functional roles;
c) firm's willingness and capacity for internal change in response to external environmental conditions;
d) extent to which customers' comments and recommendations drive changes in the firm.

6) Trust: This continuous variable was measured using a three-item scale (alpha = 0.70). Following Mayer *et al.* [35], trust was measured by

a) the extent to which industrial firm participants were willing to share ideas, feelings, and specific goals with the university center;
b) had confidence in the center's competence and abilities as well as its motives and fairness in sharing these abilities;

TABLE III
DESCRIPTIVE STATISTICS: MEANS, STANDARD DEVIATIONS, AND CORRELATIONS

Variable	Mean	s.d.	1	2	3	4	5	6	7
1) Knowledge Transfer Activities	.07	1.55							
2) Technology Transfer Activities	.09	1.1	.37***						
3) Organization Structure	4.4	1.1	.19**	-.11					
4) Stable & Direction-Oriented Culture	4.9	1.3	.58***	.38***	-.06				
5) Flexible & Change-Oriented Culture	4.8	1.1	.12***	.29***	-.17*	.74***			
6) Trust	5.3	1.0	.24***	.20**	-.09	.11	.13*		
7) Customized University Policies	5.5	1.6	.08	.30***	-.08	-.01	.15*	.10	
Control Variable									
8) Firm Size	660	71.4	.08	.16*	.07	-.04	-.07	.03	.04

N = 189 * = p < .05 ** = p < .01 *** = p < .001

c) perceived that the university center adheres to a set of principles that the firm finds acceptable.

7) University Policies for IPR, Patent Ownership, and Licensing: This single-item continuous variable measured the extent to which the university research center was willing to customize contractual agreements for IPR, patent ownership, and licensing in order to meet the firm's specific needs [6].

8) Firm Size: This single-item variable was measured by a continuous scale using the number of employees within the industrial firm [9].

IV. RESULTS

The descriptive statistics and correlation matrix are provided in Table III. The correlation matrix indicates that a number of the independent variables are highly related to the two dependent variables.[4] Since some of the independent variables were significantly correlated to one another, most notably stable, direction-oriented cultures and flexible, change-oriented cultures, a multicollinearity analysis was conducted.[5] Multicollinearity does not appear to be a serious concern since we found that the variance inflation factors (VIFs) for the culture variables were 2.8 and 2.9, respectively, while none of the VIFs for any of the remaining variables exceeded 1.2 [24].

The results of multiple regression analyses are shown in Table IV. Table IV provides the results for Model 1 where knowledge transfer activities is the dependent variable and Model 2 where technology transfer activities is the dependent variable. Within each model, a separate analysis was conducted for the control variable, firm size (Models 1a and 2a) followed by the inclusion of all independent variables (Models 1b and 2b). Our five hypotheses were tested by comparing the beta coefficients of each of the independent variables generated for each of the two dependent variables (Model 1 and Model 2) [56]. A t-test using the Fisher transformation of the beta coefficients being compared, i.e., a Z-scores test, was used to measure the difference between independent variable regression betas from this nonindependent sample [47]. The t-test results provide support for four of our five hypotheses (right most column of Table IV).

Consistent with hypothesis 1, we found that more mechanistic firm structures are associated more with knowledge transfer activities than with technology transfer activities. The t-test of the difference between the two beta coefficients (i.e., +0.14 for knowledge transfer activities compared to −0.04 for technology transfer activities) was highly significant ($t = 4.61, p < 0.001$). The T-tests also indicate that flexible and change-oriented cultures are more related to technology transfer activities than to knowledge transfer activities (0.25 versus 0.07, $t = 1.78$, $p < 0.05$) supporting hypothesis 2(a). Table IV shows that stable and direction-oriented cultures are more related to knowledge transfer activities $(+0.48)$ than to technology transfer activities $(+0.31)$ providing support for hypothesis 2(b) ($t = 1.67$, $p < 0.05$). In support of hypothesis 4, we found that more customized university policies for IPR, patent ownership, and

[4] To address the possible effects of mono-method bias an additional interitem correlation analysis was conducted [47]. The average interitem correlation among all the variables in this study revealed a mean of +0.12 indicating a slight positive response bias. The possible effects of this bias are presented in Section V.

[5] To empirically validate that our two culture constructs were indeed distinct, a principal components Varimax rotation factor analysis was conducted. The results of this analysis revealed two separate factors. The first factor, stable and direction-oriented culture had an eigenvalue of 3.97 and included the four items of long-term purpose and clear direction (loading = 0.85), shared vision (loading = 0.78), consistency and predictability (loading = 0.77), and high member agreement (loading = 0.52). The second factor, flexible and change-oriented culture, had an Eigenvalue of 1.1 and included the four items of member participation in decisions (loading = 0.87), collaboration across functional roles (loading = 0.79), change in response to environmental conditions (loading = 0.58), and customer recommendations drive decisions (loading = 0.56).

TABLE IV
MULTIPLE REGRESSION ANALYSES

Knowledge Transfer Activities			Technology Transfer Activities			
Variables	**Model 1a** Std Beta	**Model 1b** Std Beta	**Variables**	**Model 2a** Std Beta	**Model 2b** Std Beta	**T-Test** Difference between Betas from Models 1b and 2b
Control Variable			Control Variable			
Firm Size	.08	.05	Firm Size	.18**	.16**	
Independent Variables			Independent Variables			
Organization Structure		.14**	Organization Structure		-.04	4.61***
Stable & Direction-Oriented Culture		. 48***	Stable & Direction-Oriented Culture		.31***	1.67*
Flexible & Change-Oriented Culture		.07	Flexible & Change-Oriented Culture		.25***	1.78*
Trust		.17**	Trust		.18**	0.10
Customized University Policies		.06	Customized University Policies		.26***	4.83***
Overall F	1.9	16.3***	Overall F	5.1*	18.1***	
Adjusted R^2	.02	.29	Adjusted R^2	.09	.34	
ΔAdjusted R^2 within Model 1		.27***	ΔAdjusted R^2 within Model 2		.25***	

N = 189
* = p < .05
** = p < .01
***=p<.001

licensing were more associated with technology transfer activities (0.26) than knowledge transfer activities (0.06), $t = 4.83$, $p < 0.001$. Contrary to our prediction, we did not find support for hypothesis 3. Instead, our findings suggest that the firm's trust of its university research center partner is just as important for technology transfer activities $(+0.18)$ as it is for knowledge transfer activities $(+0.17)$ since the difference between the beta coefficients $(t = 0.10)$ was not significant. Fig. 1 helps to clarify our findings.

Finally, Table IV shows that our control variable, firm size, is an important factor for technology transfer activities $(p < 0.001)$ but not so for knowledge transfer activities. While large firm size appears important for technology transfer, a comparison of Models 2a and 2b indicates that in total our independent variables explain a significantly higher portion of the variance for activities associated with technology transfer (adjusted $\Delta R^2 = 0.25,\ p < 0.001$).

V. DISCUSSION AND IMPLICATIONS

The results of this study support our notion that knowledge transfer and technology transfer are distinct constructs that involve different kinds of activities and are facilitated by different organizational factors. Each of these facilitating organizational factors could, therefore, be considered a lever that acts as an enabler for either knowledge transfer or technology transfer activities.

We used the 7-S framework as our theoretical grounding to identify organizational factors of interest. Multiple regression analysis in combination with paired-samples T-tests of the regression beta coefficients [56] showed that knowledge transfer and technology transfer are independently related to most of the organizational context variables examined here. Following the dual-core model [12], we found that mechanistic structures facilitated knowledge transfer activities more than they did for technology transfer activities. Our results also showed that stable and direction-oriented cultures are highly related to knowledge transfer activities. Regarding technology transfer activities, we found that flexible and change-oriented cultures and more customized university policies for IPR, patent ownership, and licensing facilitated these activities while contrary to our expectation, trust proved equally important for both knowledge transfer and technology transfer activities.

Based on our results, three issues are worthy of further discussion. First, is the role of trust in I/U relationships—it appears to serve as the glue that helps cement I/U alliances together. Our findings imply that when a high level of trust exists, the firm is more willing to share its unique technology and knowledge requirements with its university research center partner. This creates a climate that is conducive for joint activities between the two organizations. The firm's trust of its university partner may reduce any perceived power differences between the partners thereby replacing formal monitoring with social controls [43], [54]. It also appears that trust is crucial in aiding the processes involved with the transfer of all types of know-how, whether this know-how is tacit or explicit. However, despite the benefits of trust in facilitating both technology and knowledge transfer, we must consider trust's temporal nature and the importance of other contextual factors that were not examined here [35]. For example, changes in the university research center's leadership, untrustworthy actions by the university research center, and/or new partnership alternatives can quickly change the firm's level of trust in its university partner. Thus, trust's effect on both knowledge transfer and technology transfer is complex and tenuous.

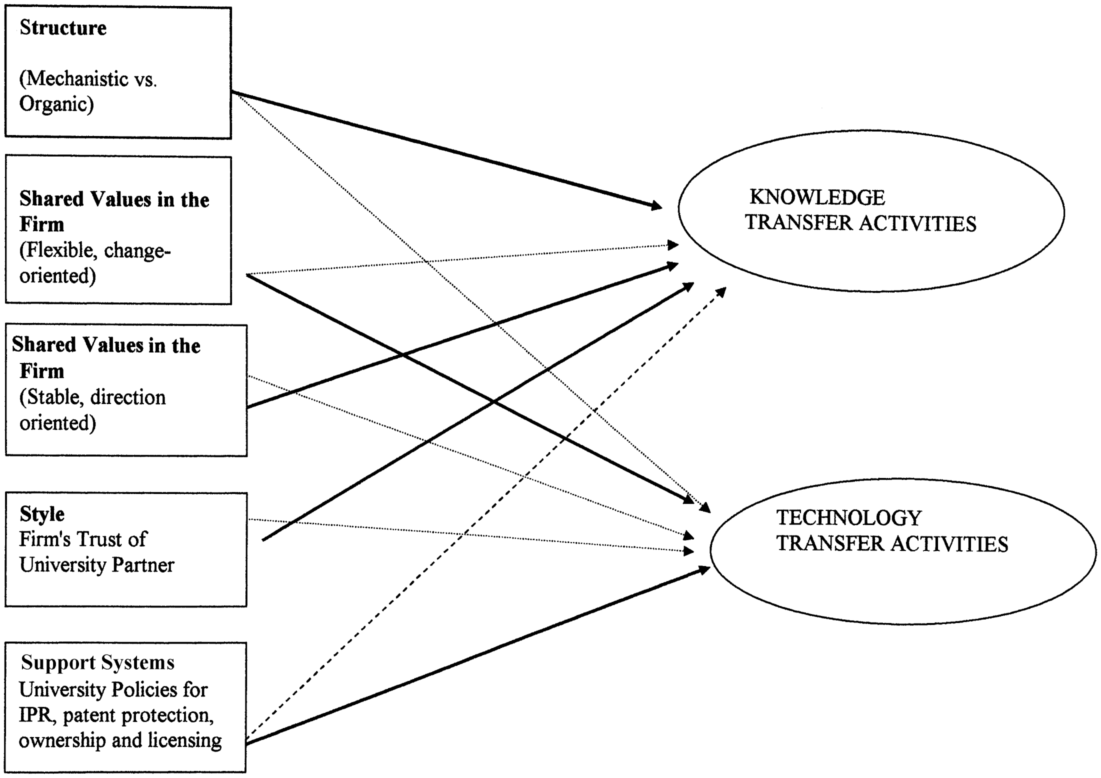


Fig. 1. Organizational Context factors that facilitate knowledge transfer and technology transfer activities. (Bold lines represent stonger relationships.)

Second, our results show that flexible and change-oriented cultures were more associated with technology transfer activities while stable and direction-oriented cultures were more associated with knowledge transfer activities. We believe however, that elements of stable direction oriented cultures and flexible change oriented cultures are necessary for both activities. Knowledge transfer and technology transfer are dynamic processes where organizations need to initiate, assimilate and institutionalize the transferred knowledge or technology. Characteristics of stable and direction-oriented cultures and flexible change-oriented cultures both play different roles in enabling the initiation, assimilation, and institutionalization of technology and knowledge transfer. On the one hand, being flexible and change-oriented makes an organization more aware of technology and knowledge outside the organization's boundaries. Being more flexible and change-oriented also creates the motivation within the organization to initiate the transfer of new technologies and knowledge. On the other hand, being more stable and direction-oriented better allows for the assimilation and institutionalization of the transferred practices [49]. This analogy coincides with the notion that organizations need to be ambidextrous for adopting innovations successfully since the initiation and implementation stages of innovation are aided by different types of organizational structures [12], [39], [51], [65]. Organizations may, therefore, need to superimpose organic structural characteristics on mechanistic structures or vice versa depending on whether technology or knowledge transfer activities are an organizational priority.

The apparent significance of culture found in this study further supports a consequential tenet in the literature that culture is an influential factor for both organizational activities and firm performance [14], [27], [53], [60]. Combining our results with findings from previous studies, it appears that the *right culture* may have a two-fold effect on firm performance. The right culture raises the level of focus on task-related activities while facilitating the acquisition of external knowledge and technologies which can further enhance the quality and quantity of performing task-related activities.

Third, our results indicate that while firm size matters when it comes to technology transfer, it appears nonconsequential for knowledge transfer. We believe this finding may reflect two aspects. First, due to a larger resource base [46] larger firms are simply involved in more technology transfer initiatives. Second, since firms of all sizes are now working feverishly to create and acquire new knowledge [17], [23], other contextual factors like structure, culture, and trust play a more significant role in the knowledge transfer process than just mere size.

Overall, the findings from this study imply that managers in organizations need to recognize and apply the differences in the organizational levers illuminated here to facilitate knowledge and technology transfer activities. Most organizations, however, usually engage in transferring and assimilating both new technologies and new knowledge. Therefore, it will be increasingly necessary for firms to combine elements of different types of structures (mechanistic and organic), or different cultural types in order to create more effective organizations that are both flexible to adapt and have the ability to quickly integrate these changes into the organization's routines.

VI. Limitations and Suggestions For Future Research

Since I/U relationships involve both industrial firms and universities, our primary focus on the industrial firm's perspective limits the scope of our model. By concentrating on factors that relate to both the firm and the university research center future studies could expand upon our findings. Moving forward, researchers could examine a number of promising areas such as the effect of university research center and industrial firm cultural compatibility, effective versus ineffective leadership in the firm and university center, personality clashes between interacting individuals, and the existence or degree of shared goals.

Second, we looked at the behaviors and the processes associated with knowledge transfer and technology transfer rather than focusing on specific knowledge or technology transfer outcomes. We assume that higher levels of certain behaviors indicate that more technology and more knowledge are being exchanged. Future studies should attempt to measure outcomes of knowledge and technology transfer in addition to the behaviors and processes associated with it.

Third, in collecting our survey questionnaire data, we were fortunate to have senior-level managers from a large number of firms in a wide cross-section of industries participate in the study. Much of the data collected in this study were from single-source respondents who single-handedly described complex organizational characteristics such as their firm's structure and culture. Collecting data from multiple respondents in each of the firms could have enhanced the data's richness. Additionally, since the data for both the dependent and independent variables were collected from the same person at the same time, common-method bias does exist. In examining the possible effect of this bias, an additional analysis showed that the average inter-item correlation among all the variables had a mean of $+0.12$ [47]. This positive result indicates a slight right-hand skew in the data. A certain level of caution is, therefore, needed in interpreting these results despite the strong associations found here. Finally, we must emphasize that this cross-sectional study has merely provided a description of a complex phenomenon. Future research capturing the temporal aspect of I/U relationships could provide additional insights related to cause and effect dynamics.

References

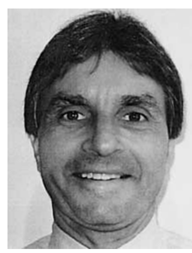
[1] Z. J. Acs and D. Audretsch, *Innovation and Small Firms*. Cambridge, MA: MIT Press, 1990.
[2] T. Allen, *Managing the Flow of Technology*. Cambridge, MA: MIT Press, 1984.
[3] J. B. Barney, "Organizational culture: Can it be a source of sustained competitive advantage?," *Acad. Manage. Rev.*, vol. 11, pp. 656–665, 1986.
[4] F. Betz, "Industry-university partnerships," in *Handbook of Technology Management*, G. Gaynor, Ed. New York: McGraw-Hill, 1996, ch. 8.
[5] R. E. Bohn, "Measuring and managing technological knowledge," *Sloan Manage. Rev.*, vol. 36, pp. 61–73, 1994.
[6] D. J. Bower, "Successful joint ventures in science parks," *Long Range Plan.*, vol. 26, no. 6, pp. 114–120, 1993.
[7] T. Burns and G. M. Stalker, *The Management of Innovation*. London, U.K.: Tavistock, 1961.
[8] W. Cohen and D. Levinthal, "Absorptive capacity: A new perspective on learning and innovation," *Admin. Sci. Quart.*, vol. 35, pp. 128–152, 1990.
[9] H. Corsten, "Technology transfer from universities to small and medium-sized enterprises-an empirical survey from the standpoint of such enterprises," *Technovation*, vol. 6, pp. 57–68, 1987.
[10] R. M. Cyert and P. S. Goodman, "Creating effective university-industry alliance: An organizational learning," *Org. Dynam.*, vol. 25, no. 4, pp. 45–57, 1997.
[11] D. Cyr, "High tech, high impact: Creating Canada's competitive advantage through technology alliances," *Acad. Manage. Exec.*, vol. 13, pp. 17–28, 1999.
[12] R. L. Daft, "A dual-core model of organizational innovation," *Acad. Manage. J.*, vol. 21, pp. 193–210, 1978.
[13] T. K. Das and B. S. Teng, "Between trust and control: Developing confidence in partner cooperation in alliance," *Acad. Manage. Rev.*, vol. 23, pp. 491–512, 1998.
[14] T. Deal and A. Kennedy, *Corporate Cultures: The Rites and Rituals of Corporate Life*. Reading, MA: Addison-Wesley, 1982.
[15] D. Denison and A. Mishra, "Toward a theory of organizational culture and effectiveness," *Org. Sci.*, vol. 6, no. 2, pp. 204–223, 1995.
[16] R. Garud and P. R. Nayyar, "Transformative capacity: Continual structuring by intertemporal technology transfer," *Strat. Manage. J.*, vol. 15, no. 5, pp. 365–385, 1994.
[17] D. A. Garvin, "Building a learning organization," *Harv. Bus. Rev.*, pp. 78–92, July–Aug. 1993.
[18] E. Geisler, "Industry-university technology cooperation: A theory of inter-organizational relationships," *Technol. Anal. Strat. Manage.*, vol. 7, pp. 217–229, 1995.
[19] D. Gerwin, V. Kumar, and S. Pal, "Transfer of advanced manufacturing technology from Canadian universities to industry," *Technol. Transfer*, vol. 12, pp. 57–67, Spring–Summer 1992.
[20] M. Gittelman, "From technology transfer to knowledge acquisition: Effective strategies for university-firm linkage," in *Acad. Manage. Meet.*, Toronto, Aug. 2000.
[21] S. Gopalakrishnan and F. Damanpour, "The impact of organizational context on innovation adoption in commercial banks," *IEEE Trans. Eng. Manage.*, vol. 47, pp. 1–13, Feb. 2000.
[22] G. Gordon and N. DiTomaso, "Predicting corporate performance from the strength of corporate culture," *J. Manage. Stud.*, vol. 29, no. 6, pp. 783–798, 1992.
[23] R. M. Grant, "Toward a knowledge-based theory of the firm," *Strat. Manage. J.*, vol. 17, pp. 109–121, Winter Special Issue 1996.
[24] J. Hair, R. Anderson, R. Tatham, and W. Black, *Multivariate Data Analysis*. Englewood Cliffs, NJ: Prentice-Hall, 1995.
[25] G. Hamel and C. K. Prahalad, "Strategic intent," *Harv. Bus. Rev.*, vol. 67, no. 3, pp. 63–76, 1989.
[26] G. Hofstede, D. Neuijin, D. Ohayv, and G. Sanders, "Measuring organizational cultures: A qualitative and quantitative study across 200 cases," *Administr. Sci. Quart.*, vol. 35, pp. 286–316, 1990.
[27] R. M. Kanter, *The Change Masters: Innovations for Productivity in the American Corporation*. New York: Simon and Schuster, 1983.
[28] R. Lawrence, *Can America Compete?*. Washington, DC: Brookings Inst., 1984.
[29] N. S. Levinson and A. Minoru, "Cross-national alliances and interorganizational learning," *Org. Dyn.*, vol. 24, no. 2, pp. 50–63, 1995.
[30] R. Lewicki and B. Bunker, "Developing and maintaining trust in work relationships," in *Trust in Organizations: Frontiers of Theory and Research*, R. M. Kramer and T. R. Tyler, Eds. Newbury Park, Ca: Sage, 1995, pp. 114–139.
[31] J. Lewis and A. Weigert, "Trust as social reality," *Social Forces*, vol. 63, pp. 967–985, 1985.
[32] M. J. Lynskey, "The transfer of resources and competencies for developing technological capabilities—the case of fujitsu-ICL," *Technol. Anal. Strat. Manage.*, vol. 11, no. 3, pp. 317–336, 1999.
[33] M. Maidique and R. Hayes, "The art of high technology management," *Sloan Manage. Rev.*, vol. 25, pp. 18–31, 1984.
[34] J. Martin, M. Feldman, M. Hatch, and S. Sitkin, "The uniqueness paradox in organizational stories," *Administr. Sci. Quart.*, vol. 28, pp. 438–453, 1983.
[35] R. Mayer, J. Davis, and F. Schoorman, "712. An integrative model of organizational trust," *Acad. Manage. Rev.*, vol. 20, pp. 709–734, 1995.
[36] Nat. Sci. Board, *Science and Engineering Indicators*. Washington, DC: U.S. Govt. Printing Office, 2000.
[37] Nat. Sci. Board, *Science and Engineering Indicators*. Washington, DC: U.S. Govt. Printing Office, 1996.
[38] Nat. Sci. Board, *University-Industry Research Relationship: Myths, Realities, and Potentials, Fourteenth Annual Report*. Washington, DC: U.S. Govt. Printing Office, 1982.
[39] W. R. Nord and S. Tucker, *Implementing Routine and Radical Innovation*. Lexington, MA: Lexington, 1987.
[40] I. Nonaka, "A dynamic theory of organizational knowledge creation," *Org. Sci.*, vol. 5, no. 1, pp. 14–24, 1994.
[41] A. L. Oliver and J. P. Liebeskind, "Three levels of networking for sourcing intellectual capital in biotechnology: Implication for studying interorganizational networks," *Int. Stud. Manage. Org.*, vol. 27, no. 4, pp. 76–103, 1998.
[42] T. J. Peters and B. Waterman, *In Search of Excellence*. New York: Harper & Row, 1982.

[43] J. Pfeffer and G. Salancik, *The External Control of Organizations: A Resource Dependence Perspective*. New York: Harper & Row, 1978.
[44] D. Phllips, "New alliance for policy and the conduct of research and education," *Int. J. Technol. Manage.*, vol. 6, pp. 478–487, 1991.
[45] R. Reams, *University-Industry Research Partnerships*. Westport, CT: Quorum, 1986.
[46] M. Rosner, "Economic determinants of organizational innovation," *Administr. Sci. Quart.*, vol. 12, pp. 614–625, 1968.
[47] R. Rosenthal and R. Rosnow, *Essential of Behavioral Research*. New York: McGraw-Hill, 1991.
[48] Rotter, "Interpersonal trust, trustworthiness and gullibility," *Amer. Psychol.*, vol. 26, pp. 433–452, 1980.
[49] M. Santoro and S. Gopalakrishnan, "The institutionalization of knowledge transfer activities within industry-university collaborative ventures," *J. Eng. Technol. Manage.*, vol. 17, pp. 299–319, 2000.
[50] E. Schein, "Organizational culture," *Amer. Psychol.*, vol. 45, no. 2, pp. 109–119, 1990.
[51] W. R. Scott, *Organizations: Rational, Natural, and Open Systems*. Englewood Cliffs, NJ: Prentice-Hall, 1992.
[52] F. Sen and A. H. Rubenstein, "External technology and in-house R&D's facilitative role," *J. Prod. Innov. Manage.*, vol. 6, no. 2, pp. 123–138, 1989.
[53] L. Smircich, "Concepts of culture and organizational analysis," *Admin. Sci. Quart.*, vol. 28, pp. 339–358, 1983.
[54] K. G. Smith, S. J. Carroll, and S. J. Ashford, "Intra-And Interorganizational Trust as Foundations for Interpersonal Cooperation in Organizations," *Acad. Manage. Rev.*, vol. 38, pp. 7–23, 1995.
[55] J. W. Spencer, "How relevant is university-based scientific research to private high technology firms? A U.S.—Japan comparison," in *Proc. Academy of Management Annu. Meeting*, Toronto, ON, Canada, Aug. 2000.
[56] SPSS, Inc., *SPSS for Windows Base System User's Guide, Release 10.0*. Chicago, IL: SPSS, Inc., 1999.
[57] SRI International, *The Impact on Industry of Interaction With Engineering Research Centers*. Arlington, VA: Science and Technology Policy Program, 1997.
[58] J. D. Thompson, *Organizations In Action*. New York: McGraw-Hill, 1967.
[59] L. G. Tornatzky and M. Fleischer, *The Processes of Technological Innovation*. Lexington, MA: Lexington, 1990.
[60] H. Trice and J. Beyer, "Studying organizational culture through rites and ceremonials," *Acad. Manage. Rev.*, vol. 9, pp. 653–669, 1984.
[61] G. VonKrogh, K. Ichijo, and I. Nonaka, *Enabling Knowledge Creation*. New York: Oxford Univ. Press, 2000.
[62] O. Williamson, *Markets and Hierarchies*. New York: Free Press, 1975.
[63] Wittgenstein, *Philosophical Investigations*. New York: Macmillan, 1958.
[64] P.-K. Wong, "University-industry technological collaborations in singapore: Emerging patterns and industry concern," *Int. J. Technol. Manage.*, vol. 18, no. 3,4, pp. 270–284, 1999.
[65] R. W. Zmud, "Diffusion of modern software practices: Influence of centralization and formalization," *Manage. Sci.*, vol. 28, pp. 1421–1431, 1982.

Shanthi Gopalakrishnan received the MBA degree from the Jamnalal Bajaj Institute of Management Studies, India, and the Ph.D. degree in organization management from Rutgers University, Newark, NJ.

While in India, she worked in sales and product management for a diversified consumer and industrial products company. She is currently an Associate Professor of management with the School of Management, New Jersey Institute of Technology, Newark. She has published articles in the IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, *Journal of Engineering and Technology Management*, *Omega—The International Journal of Management Science*, *The Journal of High Technology Management Research*, *R&D Management*, *Journal of Management Studies*, *Journal of Technology Transfer*, and *Academy of Management Executive*. Her research interests include the area of innovation management, strategic management of technology, and strategic alliances.

Dr. Gopalakrishnan received two Best Research Paper Awards, one from the Technology and Innovation Management Division of the Academy of Management, in 1997, and one from the IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT in 2001. She is a member of the Academy of Management and the Eastern Academy of Management.



Michael D. Santoro received the Ph.D. degree in organization management from Rutgers University, Newark, NJ.

He is currently an Assistant Professor of Management with the College of Business and Economics, Lehigh University, Bethlehem, PA. Prior to his academic career, he spent 21 years with Automatic Data Processing, Inc. (ADP), Roseland, NJ, serving in a number of line and staff management positions. His two most recent positions were Regional Vice President of Client Relations/Operations in the Philadelphia regional processing center and Divisional Director of Strategic and Product Planning on ADP's corporate headquarters staff. He is active in the Business Policy and Strategy, Entrepreneurship, and Technology and Innovation Management divisions of the Academy of Management and serves as an *ad hoc* reviewer for a number of leading academic journals, including the IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT. His research interests include organizational strategy, entrepreneurship, strategic alliances, and the external sourcing of knowledge and new technologies. He has authored numerous published articles that have appeared in the IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, *Research Policy*, *Journal of Engineering and Technology Management (JET-M)*, *Journal of High Technology Management Research*, and *Research-Technology Management*.