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Human Resource Practices,
Knowledge-Creation Capability And
Performance In High Technology Firms

Christopher J. Collins
Cornell University

Ken G. Smith
University of Maryland

Cynthia Kay Stevens
University of Maryland

WORKING PAPER SERIES

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Chris Collins
Ken G. Smith
Cynthia Kay Stevens

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Chris Collins

School of Industrial and Labor Relations
Cornell University
387 Ives Hall
Ithaca, NY 14853
Phone: (607) 255-8859
Fax: (607) 255-1836
Cjc53@cornell.edu

Ken G. Smith

Robert H. Smith School of Business
University of Maryland
Van Munching Hall
College Park, MD 2074
Phone: (301) 405-2250
Fax: (301)405-1412
kgsmith@rhsmith.umd.edu

Cynthia Kay Stevens

Robert H. Smith School of Business
University of Maryland
Van Munching Hall
College Park, MD 20742
Tel: (301) 405-2233
Fax: (301) 405-1412
Cstevens@rhsmith.umd.edu

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ABSTRACT

This study examines the relationship among key HR practices (i.e., effective acquisition, employee-development, commitment-building, and networking practices), three dimensions of knowledge-creation capability (human capital, employee motivation, and information combination and exchange), and firm performance. Results from a sample of 78 high-technology firms showed that the three dimensions of knowledge creation interact to positively affect sales growth. Further, the HR practices were found to affect sales growth through their affect on the dimensions of knowledge-creation capability.

Human Resource Practices, Knowledge-Creation Capability And Performance In High Technology Firms

The rapid diffusion of technological innovation on a global scale has dramatically accelerated competition on a world-wide basis (Bettis & Hitt, 1995; Friedman, 1999). As competition among technology-based firms has increased, the source of competitive advantage in these firms has migrated away from tangible resources and market power to knowledge and know how (Buderi, 2000; Quinn, 1992). This trend has led scholars to begin to study the knowledge creation capability and especially how firms can develop this unique competence (Grant, 1996; Kogut & Zander 1992; Nahapiet & Ghoshal, 1998).

The present paper focuses on knowledge creation capability, which we define as the ability of a firm to develop new ideas and understandings on a continual basis. Our review of the knowledge and organizational learning literature suggests that the knowledge creation capability has three co-dependent dimensions. First, Becker (1964) proposed that a firm's human capital—the stock of knowledge, skills, and abilities (KSAs) of its workforce—enables it to innovate. In other words, firms with highly skilled and knowledgeable employees have greater “know how” and thus are more likely to develop new ideas (Starbuck, 1992). Second, Simon (1985) reasoned that new knowledge can be created only through the specific actions of individuals; thus their motivation to contribute to the organization's benefit is essential. Finally, Nahapiet and Ghoshal (1998) contended that organizations create knowledge through information combination and exchange among employees. Although information combination and exchange relies on employees' knowledge and motivation, it extends beyond these conditions in that firms must ensure that employees have access to others, perceive value in combining and exchanging ideas, and can absorb and reflect on new information.

If, as several scholars have suggested, knowledge creation capability enables firms to more effectively respond to dynamic market conditions, then it would seem of vital importance to identify how it can be developed (Grant, 1996; Kogut & Zander, 1992; Nahapiet & Ghoshal,

1998). Toward this end, several scholars have argued that human resource (HR) practices may provide a primary role (Lado & Wilson, 1994; Snell, Youndt, & Wright, 1996). Indeed, there is an emerging consensus within the strategic human resource management (SHRM) literature that HR practices and policies influence firm performance through their impact on firm capabilities (Becker & Huselid, 1998; Wright & Snell, 2000).

The purpose of this paper is to examine the relationship among key HR practices and the three dimensions of organizational knowledge-creation capability, and to link these processes and capabilities to firm performance. Specifically, we predict that four sets of HR practices and policies (i.e., effective acquisition, employee-development, commitment-building, and networking practices) would be associated with firm knowledge creation capability defined in terms of human capital, employee motivation, and information combination and exchange. Furthermore, we argue that the three dimensions of organizational knowledge-creation capability would be related to firm performance. Finally, and drawing from the SHRM literature, we predict that the three dimensions of the knowledge creation capability will mediate relationships between HR practices and firm performance. The following sections develops the logic for these relationships in greater detail.

THEORETICAL BACKGROUND AND HYPOTHESES

Knowledge Creation as a Critical Firm Capability

Blistering competition in high technology environments has led to a collective rethinking by organizational theorists of the bases for achieving and sustaining competitive advantage. One result of this is the knowledge-based view of the firm (Grant, 1996; Kogut & Zander, 1992), in which knowledge is seen as the critical resource enabling effective deployment and transformation of other resources such as money or physical plant and equipment. In this view, knowledge comprises a unique organizational resource. It “resides” and is created in the minds of individuals and thus cannot be “owned” by organizations (Simon, 1991). Yet, knowledge

creation—particularly the creation of knowledge that can be leveraged for economic profit—is facilitated by the social context in which individuals are embedded (Nahapiet & Ghoshal, 1998; Nonaka, 1991). From this perspective, it is of crucial importance to understand how both individuals and the social context in which they operate influence the capability for developing new knowledge.

Human capital. Economists have long conceptualized an individual's knowledge and experience as human capital and have shown that human capital is capable of generating differential levels of economic returns for individuals (Mincer, 1993). Similarly, the capacities of a firm's personnel limit the opportunities that the firm can pursue (Penrose, 1959). When aggregated to the firm level, it is possible to discuss an organization's human capital as the average level of education and experience among employees. Cohen and Levinthal (1990) argued that higher levels of such education and experience enable individuals to more readily understand and absorb new information to which they are exposed. This suggests that organizations with higher levels of human capital may be better equipped to create new knowledge because they begin with a stronger initial base of knowledge.

Employee motivation. A primary dilemma facing organizations is how to encourage employees to contribute their efforts for organizational gain (Coff, 1997). In knowledge-dependent organizations, employees must be willing and motivated to share their education and experience with other employees in order to generate innovation (Nonaka & Takeuchi, 1995). Pierce and Delbecq (1977) suggested that employees who are strongly identified with their work and organization may be more likely to contribute to firm innovations. Employees who are committed to their organization are more likely to look for ways to improve conditions and will be more receptive to new ideas and information (Hage & Aiken, 1970). Moreover, firms may increase information sharing among employees by fostering work climates promoting cooperation (Nonaka, 1991). Thus, employee motivation—conceptualized as aggregate

willingness and desire to contribute to organizational gain—represents an important aspect of organizational knowledge-creation capability.

Information combination and exchange. Beyond having capable, motivated employees, organizations create and leverage new knowledge by providing a social context in which employees interact with one another to exchange and combine ideas (Nonaka, 1991). Shumpeter (1934) argued that such exchanges create new knowledge by combining previously unconnected ideas or by recombining old ideas in new ways that make them more useful. Scholars (e.g., Kogut & Zander, 1992; Nahapiet & Ghoshal, 1998) have suggested that organizations are more efficient than markets at this process because they offer access to stronger, intact social networks in a context that can value and support individual contributions. Thus, when firms create an internal social context that facilitates information combination and exchange—through access to other employees who are capable of communicating and digesting new ideas and that value this process—they are more adept at creating new knowledge.

Knowledge-creation capability and firm performance. Our review suggests that knowledge-creation capability is composed of three co-dependent dimensions: human capital, employee motivation to contribute for organizational gain, and the actual information combination and exchange process. Because high tech firms operate in dynamic environments that require constant innovation, such capability appears essential for firm survival and growth. Thus, we anticipate that high tech firms, which have higher levels of human capital, employee motivation, and information combination and exchange, should demonstrate stronger firm performance. One critical indicator of performance in high tech firms is sales growth, which reflects the extent to which these firms are generating innovations or products that customers value (Rogers & Larsen, 1984). Accordingly, we propose the following hypothesis:

Hypothesis 1: The levels of human capital, employee motivation, and information combination and exchange within high technology firms will be positively related to their sales growth.

Interaction of the Dimensions of Organizational Knowledge-Creation Capability

While each of the three conditions for knowledge creation may individually lead to greater performance, the literature on organizational learning and knowledge creation suggests that they may also interact with one another to lead to higher performance. For example, a workforce with a high level of human capital is only beneficial to an organization when those employees are motivated to contribute discretionary knowledge for the good of the organization (Simon, 1991; Ulrich, 1997). Further, willingness to share personalized knowledge may only benefit the organization if there are mechanisms in place for employees to share that knowledge with one another (Nonaka & Takeuchi, 1995). Thus, each of the individual dimensions of knowledge creation may affect firm performance to a greater extent when other dimensions of knowledge creation are also present in the organization. The hypothesis tests the co-dependency of these three dimensions of knowledge creation capability.

Hypothesis 2: The three conditions for knowledge-creation capability (human capital, employee motivation, and information combination and exchange) will positively interact with one another to increase firm sales growth.

HR Practices and Organizational Knowledge-Creation Capability

If the foregoing arguments are accurate, improved understanding of how organizations promote knowledge-creation capability, may yield substantial benefits. Several scholars have suggested that strategic use of HR practices offer a primary means for promoting such conditions (e.g., Lado & Wilson, 1994; Wright & Snell, 2000). More specifically, findings across a variety of SHRM studies have shown that alternative sets of HR practices are positively related to firm performance (e.g., Arthur, 1994; Delery & Doty, 1996; Huselid, 1995; MacDuffie, 1995; Youndt, Snell, Dean, & Lepak, 1996). For example, Huselid and his colleagues have

demonstrated that a set of high performance work practices show positive relationships with outcomes ranging from stock performance to sales growth across a wide range of industries (Delaney & Huselid, 1996; Huselid, 1995, Huselid & Becker, 1996). Other data suggest that specific HR practices such as stock ownership or profit sharing are positively linked to five-year survival following initial public offerings (Welbourne & Andrews, 1996).

Although the pattern of findings is promising, less is known about the mechanisms through which HR practices affect firm performance. The assumption underlying this body of research is that HR practices themselves do not create competitive advantages; rather, the practices are thought to lead to the development of organizational capabilities which in turn elicit competitive advantages (Lado & Wilson, 1994; Mueller, 1996). However, several features of the existing empirical studies complicate attempts to isolate these mediating links. One issue is the use of cross-industry samples. While this enhances generalizability, it is likely that the organizational capabilities needed for competitive advantage differ across industries. As a result, it may be difficult for such studies to establish specific links between HR practices, organizational capabilities, and firm performance. Because the present study was limited to high tech firms and specified knowledge-creation capability as the central focus, we minimized the potential for this issue to interfere with interpretation of our results.

A second issue concerns the set of HR practices examined, which differ in both scope and specific items across studies (Becker & Gerhart, 1996). Again, this approach suggests that the positive results across studies are robust, but makes it difficult to pinpoint specific causal links. We addressed this issue by our literature review that revealed a set of conceptually distinct HR practices that may be related in different ways and degrees to the three dimensions of knowledge creation capability. Although our approach limits direct comparisons between our findings and those of studies using broader sets of HR-practices (e.g., high performance work practices; Huselid, 1995), it improves conceptual clarity concerning which HR practices are linked with knowledge-creation capability.

To determine the HR practices appropriate for investigation, we identified the alternative types of practices in the literature that may be associated with organizational knowledge-creation capability. For example, organizational levels of human capital may be increased through recruitment and selection (i.e., acquisition), employee development, or both types of practices (Snell & Dean, 1992). Moreover, aggregate employee motivation would be enhanced through HR practices designed to build commitment (MacDuffie, 1995). Finally, information combination and exchange might be enhanced through HR networking practices. Consistent with prior SHRM research (e.g., Youndt et al., 1996; Delery, 1998), we assumed that individual practices within each firm could affect each of the three dimensions of the organizational knowledge-creation capability, but that the use of certain practices will be associated more strongly to some knowledge creation dimensions than others. Below we define and explain each set of practices as well as their relationship to the organizational knowledge-creation capability dimensions.

HR acquisition practices and human capital. Firms requiring higher levels of employee education and experience can use extensive recruiting and selective staffing practices as a means for improving their human capital (Snell & Dean, 1992; Koch & McGrath, 1996). Several specific practices have been shown to be effective. For example, recruitment can be enhanced through the use of multiple recruiting sources to build larger applicant pools (Koch & McGrath, 1996). Because candidates with specialized knowledge, skills, and abilities (KSAs) command a premium in the labor market, above-market starting salaries and other recruitment inducements (e.g., signing bonuses) can attract higher levels human capital (Snell & Dean, 1992). In addition to recruitment, selective screening practices that increase the amount of relevant information gathered permit firms to identify and hire employees with stronger KSAs (Hunter & Schmidt, 1982).

Hypothesis 3: Use of effective HR acquisition practices (e.g., extensive recruitment, above-average starting salaries, signing bonuses, and rigorous selection techniques) will be positively related to the level of human capital.

Employee-development practices and human capital. A second strategy for improving human capital is to directly increase the education and experience within an existing workforce. To develop higher levels of education or experience, firms can provide training in-house or access to continuing education through tuition reimbursement programs (Becker, 1964, Snell & Dean, 1992). Firms can also increase specialized knowledge or skills through the use of performance appraisals to identify needed KSAs and implement development plans designed to improve those KSAs (Latham & Wexley, 1981).

Hypothesis 4: Use of effective employee-development practices (e.g., developmental performance appraisals, formal training programs, and access to reimbursement for additional training or continuing education) will be positively related to the level of human capital.

Commitment-building practices and employee motivation. Employees may be more willing to contribute their specialized KSAs for organizational gain when their organizations signal similar levels of commitment to employees (Tsui, Pearce, Porter, & Tripoli, 1997). Similarly, Schuler (1989) and MacDuffie (1995) have argued that structured HR practices oriented toward motivating employees to contribute their effort for organizational gains are the most effective ways to achieve high commitment.

HR practices associated with improved employee commitment include a variety of compensation programs that emphasize extrinsic and intrinsic rewards (Milkovich, 1987). For example, stock ownership is an effective tool for aligning employee motivation with organizational goals, increasing organizational commitment, and encouraging employees to contribute discretionary effort (Milkovich, 1987). Tying compensation to group or organizational performance increases employees' willingness to cooperate with each other, whereas tying

compensation to specific goals associated with knowledge creation (e.g., providing incentives for new ideas) may encourage employees to innovate (Davenport & Prusak, 1998). Furthermore, organizations that advertise openings internally and give preference to internal (versus external) candidates signal their commitment to existing employees and provide incentives for long-term relationships. Finally, the use of flexible policies, such as flexible work hours and “casual clothing” policies, may increase employee motivation (Munk, 1998).

Hypothesis 5: Use of effective commitment-building practices (e.g., stock ownership, group or organizational incentives, internal promotion policies, flexibility programs) will be positively related to the level of employee motivation in high tech firms.

Networking practices and information combination and exchange. HR practices can also be used to improve the level of information combination and exchange within firms. For example, Galbraith (1973) argued that organization design and specific management practices are effective for facilitating the flow and integration of information among employees. One such practice is the use of a team-based work units. Employees are more likely to be exposed to new information when they work and interact in cross-functional teams (Galbraith, 1973).

Employees are better able to combine and exchange information in ways that support innovation if they also have connections to widely dispersed individuals and work units (Nahapiet & Ghoshal, 1998). Firms can accomplish this through job rotation, in which employees move horizontally across a range of jobs to gain exposure to a variety of employees and work units. They can also build social connections among employees through the company sponsored events such as sports teams and parties (Fromartz, 2000). Finally, firms can directly improve information combination and exchange by mentoring—pairing inexperienced employees with experienced managers or colleagues (Noe, 1999).

Hypothesis 6: Use of networking practices (e.g., team-based job design, job rotation, mentoring, and socialization activities) will be positively related to the level of information combination and exchange in high tech firms.

Mediation of the HR practice @ firm performance relationship. Although scholars have argued that HR practices do not lead directly to firm performance, there are few empirical tests of models in which HR practices influence the organizational capabilities, which in turn, affect performance (McMahan, Virick, & Wright, 1998). Based on robust relationships identified by prior research (e.g., Huselid, 1995; Youndt et al., 1996), we did expect to find positive relationships between HR practices and firm performance. However, we anticipated that these relationships would be mediated by the three dimensions of knowledge-creation capability.

Hypothesis 7: The HR practices → firm performance relationship will be mediated by human capital, employee motivation, and information combination and exchange.

METHOD

Overview of the Research Process

Our target population was high-tech firms in the Mid-Atlantic region. For each firm, data were collected from three sources: (a) publicly available financial records (to assess firm performance); (b) detailed surveys completed by core workers (to assess human capital, employee motivation, and information combination and exchange); and (c) a detailed survey completed by the senior HR manager (to assess HR practices for core employees).

Sample and Research Procedures

Respondents. Companies were targeted for study inclusion based on two criteria. First, we excluded any companies that did not conform to the following characteristics of high-technology firms, which "... emphasize invention and innovation in their business strategy, deploy a significant percentage of their financial resources to R&D, employ a relatively high percentage of scientists and engineers in their workforce, and compete in worldwide, short-life-

cycle product markets” (Milkovich, 1987: 80). Our second criterion was firm size: we contacted only firms that employed more than 50 employees to ensure that all participating companies had formally established systems of HR practices.

A list of 284 companies meeting these criteria were developed using two sources: the 1998 Mid-AtlanTech Almanac (a publication with company profiles on over 200 regional technology firms) and a contact at a regional high-technology council. Of these firms, 73 were either no longer in business, had recent senior-management turnover, or had been recently acquired by another firm. Of the remaining 211 firms, 85 agreed to participate in the study. Due to missing data on some measures for 7 firms, the final sample size was 78 companies (37% participation rate). The companies that agreed to participate did not differ from nonparticipants in either reported sales ($t_{211} = 1.485$, ns) or number of employees ($t_{211} = 1.218$, ns).

Individual respondents were identified by each company’s CEO, who was asked to identify: (a) up to 15 core employees, defined as employees “who are critical for creating new knowledge or developing innovations within your organization,” and (b) a senior HR manager. To increase the participation rate within firms, we included signed endorsements from the CEO with each survey. An average of 5.22 core employees responded within each firm; we obtained an overall internal participation rate of 56% for core employees and 100% for HR managers.

Variable Definitions and Measurement

Because our focus was on firm-level predictors and performance, we developed firm-level estimates of human capital, employee motivation, and information combination and exchange. In so doing, we followed Klein, Dansereau, and Hall (1994) by wording most survey items to reflect firm-level constructs. We also calculated interclass correlations to test the appropriateness of our aggregation procedures (Bliese, 1998; James, 1982).

Human capital. We estimated human capital among core employees through survey items pertaining to their work experience and formal education. Work experience was measured using two questions regarding years of work experience in the current industry and in

the current company. These two measures were highly correlated ($r = .74$), so they were averaged to create a single measure of work experience. Formal education was measured by asking respondents to specify their years of post-high school education. Analyses indicated that education did not correlate strongly with either measure of work experience (industry experience $r = .31$; company experience $r = .36$). Becker (1964) suggested that education is conceptually different from work experience, because it is broader in nature and generalizes across industries. Therefore, we kept these two human capital indices separate in our analyses. ICCs for both measures of human capital [experience ICC(1) = .412, ICC(2) = .714; education ICC(1) = .314, ICC(2) = .688] exceeded cutoff levels suggested by Bliese (1998), supporting aggregation to a firm-level of analysis.

Employee motivation. We assessed employee motivation using established scales for three interrelated constructs: organizational commitment, job involvement, and cooperation. To measure organizational commitment, we adapted nine items developed by Porter, Steers, Mowday, and Boulian (1974; current $\alpha = .92$). We assessed job involvement by adapting the 10-item scale developed by Lodahl and Kejner (1965; current $\alpha = .91$). Finally, we measured cooperation with a seven-item measure adapted from Warr, Cook, and Wall (1979; current $\alpha = .89$). Preliminary analyses suggested reasonable discriminant validity for these three measures: (1) scale items for the three constructs of employee motivation loaded on separate components when entered into a single principal component analysis; and (2) in a factor analysis with both motivation and information combination and exchange items, scale items for the three motivation constructs loaded on separate components from the scale items for information combination and exchange. However, a higher-order principal components analysis indicated that the three scales loaded on a single component (organizational commitment = .92, job involvement = .88, cooperation = .89; eigenvalue = 2.73). Because we were interested in a composite firm-level index of employee motivation, we combined the measures into a single

index of employee motivation. ICCs [ICC(1) = .519, ICC(2) = .890] for this composite measure exceeded cutoff levels suggested by Bliese (1998), supporting aggregation to a firm-level of analysis.

Information combination and exchange.. To tap information combination and exchange within organizations, we developed 22 items based on theoretical arguments in the organizational learning and knowledge literature. These items comprised five key dimensions derived from this literature: (a) access to people or groups with specialized information (access to others; Nahapiet & Ghoshal, 1998); (b) ability to absorb and combine information that has been exchanged (combination capability; Cohen & Levinthal, 1990); (c) ability to reflect on and evaluate existing knowledge, frameworks, and premises (reflection; Argyris, 1977); (d) ability to learn from others and become aware of changes in knowledge (learning; Simon, 1991); and (e) belief that the combination and exchange of ideas yields real personal or organizational value (perceived value; Nahapiet & Ghoshal, 1998). These items were developed in several brainstorming sessions and were pre-tested on several MBA students and current managers who had high-tech work experience. Respondents were asked to assess the extent to which they agreed (1 = strongly disagree, 5 = strongly agree) with statements about information combination and exchange (see Table 1 for specific items).

A principal components analysis with varimax rotation indicated that 18 items loaded on a single component, whereas the five remaining items weakly cross-loaded on two additional components. After removing the five cross-loaded items, a second principal components analysis showed a single component with an eigenvalue of 11.72 (see Table 1 for loadings). Given strong evidence that these items represented a single factor, we combined them to form a single index of information combination and exchange. ICCs for the aggregated index [ICC(1) = .367, ICC(2) = .743] exceeded levels suggested by Bliese (1998), therefore, we averaged the individual scores across core employees within each firm to create a firm-level measure of information combination and exchange.

TABLE 1
Analysis of Information Combination and Exchange Items

Intended Subscale	Item	Loading
Access to others	Employees in this organization meet frequently to discuss work-related ideas and new developments.	.778
Access to others	Employees have difficulty getting together to exchange new ideas and developments (reverse coded).	.676
Access to others	Employees feel free to contact anyone in the organization to discuss new ideas or developments.	.632
Access to others	Employees in this organization are always available to discuss new ideas or developments.	.750
Combination capability	Employees in this firm are proficient at combining and exchange ideas to solve problems or create opportunities.	.823
Combination capability	Employees in this company do not do a good job of sharing their individual ideas to come up with new ideas, products, or services (reverse coded).	.841
Combination capability	Employees here are capable of sharing their expertise to bring new projects or initiatives to fruition.	.669
Combination capability	The employees in this company have learned to effectively pool their ideas and knowledge.	.819
Combination capability	It is rare for our employees to exchange and combine ideas to find solutions to problems (reverse coded).	.740
Reflection	Employees in this company keep each other on track concerning ideas and new developments.	.789
Reflection	Our employees track their progress overtime on ideas and new developments.	.693
Reflection	Employees here periodically reflect on what direction their efforts are taking them.	.588
Learning	Employees learn from one another on a daily basis.	.713
Learning	Employees in this company grow and develop on a daily basis from their interaction with other employees.	.664
Learning	Employees at this company walk away from their interactions with each other with more knowledge than when they started.	.666
Perceived value	Employees see benefits from exchanging and combining ideas with one another.	.698
Perceived value	The most valuable ideas seem to come when our employees pool their effort.	.687
Perceived value	Employees believe that, by exchanging and combining ideas, employees can create value for this company.	.712

HR practices. We examined four distinct sets of HR practices based on prior research and described in Hypotheses 2–5: (a) acquisition; (b) employee-development; (c) commitment-building; (d) networking. Following recommendations by Delery (1998) and procedures used by

MacDuffie (1995) and Youndt et al. (1996), each set was operationalized as an additive index of multiple HR practices. This approach assumes that organizations can improve the effectiveness in a system of HR practices either by greater use of an individual practice or by increasing the total number of practices used in the system. Items for each set were adapted from Snell and Dean (1992) and Youndt and Snell (1999) or identified through brainstorming. We pre-tested items with three HR managers from high tech firms similar to those in our sample.

Measures of HR practices were collected from a survey distributed to senior HR managers at each firm. These managers were asked to rate the extent to which they agreed (1 = strongly disagree, 5 = strongly agree) with the statements about the HR practices used in connection with core employees (whose names were listed at the top of each survey). Specific items and Cronbach's reliability estimates for each set can be found in Appendix A.

Firm performance. We operationalized firm performance as a one-year measure of sales growth, which indicates the extent to which customers value the ideas and products that a firm is producing. This measure is appropriate for our sample because, as Rogers and Larsen (1984) have argued, managers and analysts of high technology firms closely track sales growth as an indicator of firm performance. We obtained sales growth data from the Gale Directory for the fiscal year ending in June 2000, which enabled us to lag performance data for one year after collection of our predictors. Because sales figures in the Gale Directory are self-reported, we validated these estimates with sales figures from 10-K filings for 57 publicly traded firms in the sample. This analysis indicated strong relationships between both measures ($r = .84$, $p < .001$), suggesting reasonable reliability for our performance measure.

Control variables. Because the high-tech firms in our sample varied both in size (e.g., sales, number of employees) and industry, we controlled for these variables in our analyses. Research indicates that larger companies have more innovations and better financial performance than smaller companies (Keats & Hitt, 1988); therefore, we controlled for firm size

using a natural logarithmic transformation of the number of full-time employees (which controls for skewness; Kimberly, 1976). In addition, firms within an industry may differ systematically in terms of their specific environmental conditions (Huselid, 1995). Our sample included firms from six high-tech industries, including computer software, semiconductor equipment, information technology, engineering technology services, telecommunications, and bio-technology. To control for industry-specific variance, we coded each firm for industry membership and included this dummy code in our regression analyses.

RESULTS

Means, standard deviations, and correlations for each major variable appear in Table 2. Our data indicated large variance in firm size, both in terms of number of employees (85 to 16,668) and in revenues (\$1.2 million to \$4 billion). The average was 1196 full-time employees (standard deviation = 2735 employees).

Hypothesis 1: Relationship Between Knowledge-Creation Capability and Sales Growth

Hypothesis 1 predicted that firms which had higher levels human capital, employee motivation, and information combination and exchange would also have higher sales growth. To test these hypotheses, we regressed firm sales growth on both control variables and the three dimensions of knowledge-creation capability (human capital, employee motivation, and information combination and exchange). The overall regression equation explained significant variance in firm performance ($R^2 = .260$). However, as shown in Table 3, only information combination and exchange ($\beta = .517, p < .01$) was significantly related to firm performance after controlling for firm size, and industry. None of the remaining dimensions were significantly related to firm performance (years of education $\beta = .114, ns$; years of work experience $\beta = -.065, ns$; employee motivation $\beta = .193, ns$). Thus, we found mixed support for Hypothesis 1.

Table 2:
Means, Standard Deviations, Reliabilities, and Correlations^a

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. Sales Growth	15.41	24.1	—									
2. Log # of employees	5.813	1.66	.081*	—								
3. Industry sector	1.578	.856	.093	-.121	—							
4. Years of education	19.43	7.79	.263*	.269*	.102	—						
5. Years of experience	5.517	1.27	-.054	.153	.046	.189	—					
6. Employee motivation	3.671	.573	.363**	.209	-.047	.302**	.041	—				
7. Information combination & exchange	2.601	.883	.457**	.120	.008	.321**	.225*	.418**	—			
8. Acquisition practices	46.56 3	8.84 4	.296*	.151	.212	.415**	.083	.205	.270*	—		
9. Development practices	36.88	7.90	.181	.107	.104	.280*	.236*	.178	.124	.302**	—	
10. Commitment practices	48.04	7.08	.292*	.194	-.004	.220	.085	.442**	.293**	.349**	.288*	—
11. Networking practices	36.32	6.78	.302*	.241*	-.169	.229*	-.058	.242*	.405**	.368**	.223	.388**

^a N = 78 *p < .05 ** p < .01

TABLE 3
Knowledge-Creation Capability Dimensions Predicting Sales Growth^a

Step	Variables	Beta	t	Model Adj. R ²
1	Log # of employees	-.007	-.060	.260**
	Industry	-.041	-.485	
	Years of Education	.114	.928	
	Years of Experience	-.065	-.458	
	Employee Motivation	.193	1.514	
	Info. Combination & Exchange	.517**	2.401	
2	Log # of employees	-.012	-.073	.349**
	Industry	-.052	-.461	
	Years of Education	-.143	-1.045	
	Years of Experience	.104	.328	
	Employee Motivation	.141	.573	
	Info. Combination & Exchange	.314*	1.964	
	Info. Combination & Exchange × Years of Education	.352*	2.096	
	Info. Combination & Exchange × Years of Experience	-.204	-1.066	
	Info. Combination & Exchange × Employee Motivation	.272 ^T	1.733	
	Employee Motivation x Years of Education	.366*	2.166	
	Employee Motivation x Years of Experience	.045	.088	

^a N = 78, Dependent variable: Sales Growth

* p < .05 ** p < .01 ^T p < .10

Hypothesis 2: Interaction of Knowledge-Creation Capability Dimensions

Hypothesis 2 predicted that the individual dimensions of knowledge-creation capability would have a greater affect on firm sales growth to the extent that the other dimensions also are present. As shown in Table 2, we found that both the interaction of years of education and information combination and exchange ($\beta = .352$, $p < .05$) and the interaction of years of education and motivation ($\beta = .366$, $p < .05$) were significantly related to performance. In addition, the interaction of employee motivation and information combination and exchange was marginally significant ($\beta = .272$, $p < .10$). Neither of the years of experience interactions were

significant (experience x employee motivation $\beta = -.045$, ns; experience x information combination and exchange $\beta = -.204$, ns). Thus, there was mixed support for hypothesis 2. Firms that increase the level of education in their core employees experience higher sales growth to the extent that the firm also has higher levels of both employee motivation and information combination and exchange. There is also some indication that fostering an environment of employee motivation will increase firm performance to the extent that the firm also increases information exchange and combination.

Hypotheses 3-6: Relationships Between HR Practices and Knowledge-Creation Capability

Hypotheses 3 through 6 predicted that different sets of HR practices would be related to the three knowledge-creation capability dimensions of human capital, employee motivation, and information combination and exchange. Hypotheses 3 and 4 predicted that an acquisition and an employee-development set of HR practices would be significantly related to the level of human capital in the firm. Our data indicated some support for both hypotheses. As shown in Table 4, acquisition practices were significantly related to higher levels of education ($\beta = .436$, $p < .001$) but not to years of work experience ($\beta = .089$, ns). Conversely, employee-development practices were significantly related to years of work experience ($\beta = .242$, $p < .05$), but not to years of education ($\beta = -.018$, ns). In summary, both acquisition and employee-development practices contributed to levels of human capital, albeit in distinctly different ways: greater use of acquisition practices was associated with higher education levels, whereas employee-development practices were linked with greater years of experience.

TABLE 4
Regressions Predicting Knowledge-Creation Capability Dimensions^a

Dependent Variable	Independent Variables	Beta	t	Model Adj. R ²
Years of Education	Log # of employees	.288**	2.932	.335
	Industry	.046	.410	
	Acquisition practices	.436**	3.139	
	Development practices	-.018	-.132	
	Commitment practices	.166	1.245	
	Networking practices	-.045	-.166	
Years of Experience	Log # of employees	.163	1.446	.154
	Industry	.103	1.195	
	Acquisition practices	.089	.297	
	Development practices	.242*	2.016	
	Commitment practices	-.047	-.199	
	Networking practices	.077	.244	
Employee Motivation	Log # of employees	-.031	-.313	.291
	Industry	.116	1.085	
	Acquisition practices	-.056	-.112	
	Development practices	.044	.098	
	Commitment practices	.469**	4.218	
	Networking practices	.146	1.014	
Info.Combination and Exchange	Log # of employees	.014	.134	.231
	Industry	-.108	-.991	
	Acquisition practices	.098	.712	
	Development practices	-.087	-.605	
	Commitment practices	.165	1.456	
	Networking practices	.437**	4.113	

^a N = 78 * p < .05 ** p < .01

Hypothesis 5 predicted that commitment-building HR practices would be most associated with higher firm levels of employee motivation. Our data showed strong support for this hypothesis (see Table 4); use of the commitment-building practices was significantly and positively related to employee motivation ($\beta = .469$, $p < .01$). Note that none of the other HR practices showed significant relationships with employee motivation. Therefore, high tech firms that used more commitment-building HR practices, such as stock sharing plans, above market

wages, and internal promotions, were more likely to have employees motivated to contribute their efforts to organizational gain.

Finally, Hypothesis 6 predicted that networking HR practices would be linked to information combination and exchange. Again, there was strong support for this hypothesis (see Table 4), the networking practices, but none of the other sets of HR practices, were significantly related to information combination and exchange ($\beta = .437, p < .01$). Thus, our data suggest that high tech firms can increase the level of information combination and exchange through the use of HR practices such as job rotation, social events, and formal mentoring relationships.

Hypothesis 7: Mediation of Relationships Between HR Practices and Firm Performance

Hypothesis 7 predicted that the three dimensions of organizational knowledge-creation capability (human capital, employee motivation, and information combination and exchange) would mediate any observed relationships between the sets of HR practices and sales growth. Following Baron and Kenny (1986), we first examined direct relationships between HR practices and sales growth. Step 1 of Table 5 shows that both the acquisition ($\beta = .300, p < .05$) and the networking practices ($\beta = .351, p < .05$) were significantly related to firm sales growth after controlling for firm size and industry. As discussed above, all the HR practices were significantly related to at least one of the dimensions of knowledge-creation capability (i.e., human capital and information combination and exchange, respectively; see Table 4), establishing the IV \rightarrow mediator link. Finally, as shown in Table 3, neither set of HR practices remained significantly related to sales growth (acquisition $\beta = .270, ns$; networking $\beta = .184, ns$) after controlling for human capital and information combination and exchange. Thus, we found evidence that distinct HR practices lead to higher levels of revenue growth indirectly through their effect on knowledge-creation capability in high tech firms.

TABLE 5
Mediation of HR Practices-Sales Growth Relationship^a

Step	Variables	Beta	t	Model Adj. R ²
1	Log # of employees	-.018	-.166	.215
	Industry	-.046	-.402	
	Acquisition practices	.300*	1.896	
	Development practices	-.131	-.673	
	Commitment practices	.208	.627	
	Networking practices	.351*	2.071	
2	Log # of employees	-.007	-.060	.289
	Industry	-.041	-.485	
	Acquisition practices	.240	1.696	
	Development practices	-.109	-.542	
	Commitment practices	-.116	-.646	
	Networking practices	.184	1.020	
	Years of Education	.071	.501	
	Years of Experience	-.045	-.427	
	Employee Motivation	.187	1.224	
	Info. Combination & Exchange	.463**	2.316	

^a N = 78, Dependent variable: Sales Growth

* p < .05 ** p < .01

DISCUSSION

This study explored how high-tech firms use HR practices and knowledge-creation capability as levers for increasing sales growth. Specifically, we identified three dimensions of knowledge-creation capability (human capital, employee motivation, and information combination and exchange) and proposed that they are key drivers of performance in technology-based firms. Consistent with current thinking in the SHRM literature, we argued that sets of HR practices affect firm performance through their effect on knowledge-creation capability. Our results showed that knowledge-creation capability does significantly explain variance in firm performance. Our findings also suggested that SHRM researchers will benefit by examining mediating links between HR practices and performance. As Dyer and Shafer (1999) suggested, studying direct relationships between HR practices and firm performance provides little insight as to how HR practices contribute to organizational success.

The Knowledge-Creation Capability and Sales Growth

The knowledge-based view of the firm proposes that a capacity to generate new knowledge on an on-going basis is key for organizational success and survival in turbulent and dynamic environments. We argued that firms have a greater likelihood of generating new knowledge when they have higher levels of human capital, employee motivation, and information combination and exchange. We found support for the relationship between knowledge creation capability and performance; however, the relationships among these three knowledge dimensions and firm performance were somewhat more complicated than simple direct relationships. Only information combination and exchange showed a significant direct relationship to firm sales growth. This finding is consistent with Nahapiet and Ghoshal (1998), who argued that information combination and exchange is the essential means for new knowledge creation. Thus, it appears that high-tech firms that facilitate the flow of knowledge through exchange and combination of ideas among employees benefit by increasing revenue growth. Presumably these firms grow because they are better able to adapt to changes and exploit new opportunities as they arise.

Contrary to our hypotheses, neither human capital nor employee motivation showed significant direct relationships with firm performance. Instead, we found that years of education and employee motivation were only related to sales growth in the presence of high levels of one of the other dimensions of knowledge-creation capability. We found significant interactions between years of education and information combination and exchange and years of education and employee motivation when predicting sales growth. Further, we found a marginally significant interaction between employee motivation and information combination and exchange. These findings highlight the co-dependency of our three dimensions of knowledge creation capability and suggest that firms should be wary of investing money to develop one of these dimensions without also investing money in the others. For example, investing in higher levels of education in core employees does not appear to pay off in terms of sales growth unless the

firm has also invested to raise either the level of employee motivation or the ability of employees to combine and exchange information.

Moreover, the correlations in Table 2 are revealing in suggesting that exchange and combination are facilitated by employing well educated personnel and motivating them to contribute their knowledge for the good of the organization. Both years of education and employee motivation are significantly correlated with information combination and exchange, suggesting that the presence of these two dimensions of knowledge-creation capability may help to foster information combination and exchange. Future research should explore the links between human capital, motivation and the exchange and combination process in more detail. In deed, future research should also explore other dimensions which may support the exchange and combination process.

We were also somewhat surprised to find that years of work experience (a measure of company and industry-specific experience) was not significantly related to firm performance or any of the remaining knowledge-creation capability dimensions. However, most of our firms were relatively new (less than five years old) and operating in emergent industries; this creates a ceiling effect on the work experience measures. Further, if these industries are experiencing rapid and revolutionary technological changes, then previous industry experience may not be particularly beneficial for adaptation. Rather, higher levels of industry experience may limit the extent to which some firms pursue new technologies or opportunities (Christiansen, 1998). It is possible that this measure of human capital may play a more significant role in the performance of firms in more established and stable industries.

HR Practices, Knowledge-Creation Capability, and Firm Performance

Our results also have important implications for future SHRM research and firm investments in HR practices. Previous work has suggested that SHRM researchers will be better able to understand the impact of HR practices on firm performance by exploring mediating links (e.g., Becker & Huselid, 1998; Wright & Snell, 2000). However, prior studies

have not specified or tested the specific HR practices and the underlying organizational capabilities to establish these links (McMahan et al., 1998). At least in our research, we find that HR practices are indirectly related to firm performance through their effect on the knowledge-creation capability. Thus, our findings support the argument that researchers must explore mediating firm capabilities to fully understand the role of HR practices on firm performance.

Our findings also support the idea that multiple sets of conceptually distinct HR practices may have different effects on key organizational capabilities. For example, the acquisition practices were significantly related to higher levels of education but was not to work experience, employee motivation, or information combination and exchange. Similar results were found for the other sets of practices. This findings suggest that distinct sets of practices are related to performance in differential ways. Thus, we would expect that future studies may find different sets of HR practices predicting firm performance according to the underlying organizational capabilities needed for competitive advantage in those industries. Toward this end, SHRM researchers should identify the necessary firm capabilities given the business environment for their samples and use this information to identify the HR practices that may be used to build those capabilities. In so doing, they will have the potential to offer new *strategic* insights on the role of human resource management.

In a practical vein, our results suggest that firms can use sets of HR practices to build organizational knowledge-creation capability. However, firms should not invest across the board in different HR practices. Rather, they should focus on those sets of practices that are consistent with the strategic goals of the firm. For example, high tech firms, which face a dynamic environment, will benefit more from acquisition than from employee-development practices. Moreover, these firms will benefit more from investing in networking practices such as job rotation and mentoring because these practices facilitate information combination and exchange. However, knowledge-creation capability in firms facing less turbulent environments

may find that alternative practices are required. Additional research may elucidate important caveats on these relationships.

Study Limitations

While our results are potentially important, we also note several limitations. First, the study involved a field sample in which some data were collected concurrently; thus, we cannot establish causality when testing those relationships. Specifically, all data for the independent (HR practices) and mediating (dimensions of knowledge-creation capability) variables were collected at the same time, so it is impossible to determine causality. For example, firms with a reputation for innovation and new knowledge creation may be more likely to attract employees with high human capital, because highly skilled individuals are often attracted to firms who are seen as being on the cutting edge of technology (Munk, 1998). Although this was beyond the scope of our study, one method to address this problem would be to collect longitudinal data to test the predictive validity of these relationships.

Second, the core employee data were only collected from a limited number of employees within each organization and may not fully reflect the human capital, motivation, or information combination and exchange within the larger set of core employees in these firms. To manage the time and logistical problems associated with a full-firm survey, we asked CEOs to select a subset of core knowledge workers. Although this methodology offers a number of benefits, such as separate-source data, this subset may be atypical of other core employees within each firm. This is of particular concern for the large organizations, because respondents represented only a small proportion of core employees. Even though we cannot eliminate the potential bias, subsequent analyses indicated that the pattern of relationships did not vary by organizational size.

Third, as with many studies, there may be exogenous variables that affect the relationships studied. In particular, previous theoretical research has identified social capital (Nahapiet & Ghoshal, 1998), organizational culture (Nonaka, 1991), and employee trust

(Nonaka & Takeuchi, 1995) as relevant factors in the exchange of information and creation of new knowledge among employees. In addition, research on the knowledge-based view of the firm has argued that knowledge-creation capability will lead to higher financial performance by increasing firm innovation. Future research should directly explore innovations as a mediator between knowledge-creation capability and firm performance and examine the role of other dimensions that theoretically underlie new knowledge creation.

Study Strengths

Despite these limitations, our study also offers a number of strengths. First, by limiting our focus to high-tech firms, we were able to study knowledge-creation capability in an environment in which it is critical for firm survival. If knowledge creation is an important capability for all firms, as Grant (1996) suggested, then examining this process in firms for which it is most critical should yield tremendous insights. Further, our variance in firm size and industry suggest that our results should generalize to other knowledge-intensive firms facing similar environmental turbulence. Another strength was our research design: we obtained data from independent sources for each firm, including secondary financial information, core employees, and top HR executives. Because our independent, mediating, and dependent measures were collected from different sources, we avoided the potential bias associated with single sources.

Our findings are further strengthened by the use of lagged firm-performance data. This enables us to specify with some confidence that HR practices and the dimensions of knowledge-creation capability may lead to improved sales growth in high-tech firms. Finally, this research provides one of the first full tests of a mediated relationship between HR practices and firm performance. Most researchers do not test the proposed mediators of this relationship because the data on organizational capabilities are difficult to obtain (Becker & Gerhart, 1996). By establishing these important links, our study provides guidance for future conceptual and empirical work on this important topic.

Conclusion

In conclusion, this study provides some preliminary evidence that HR practices are significantly related to alternative dimensions of the knowledge creation process and that knowledge-creation capability is related to firm growth. Moreover, we observed that certain HR practices influenced firm sales growth through their impact on the knowledge-creation capability. Although we found that the relationship between different dimensions of the knowledge-creation capability and sales growth more complex than we originally expected, we are hopeful that our conceptualization of the knowledge creation capability will inspire more empirical attention to the concept. A better understanding of the knowledge-creation capability could be of great practical benefit to managers facing high velocity environments.

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APPENDIX A

HR Practice Measures

HR Acquisition Practices ($\mu = .84$)

1. We use multiple sources (e.g., universities, newspapers, web site) to recruit candidates.
2. We develop a large pool of applicants from which to choose for open positions.
3. We devote significant resources to develop a pool of potential employees.
4. We use incentives (e.g., stock options, sign-on bonuses) to attract candidates.
5. We offer higher starting salaries than competitors to attract candidates.
6. We use multiple screening devices besides interviews to select employees.
7. We use an extensive screening system to select candidates for open positions.
8. We spend a great deal of money to insure that we hire the right person for the job.

Employee-Development Practices ($\infty = .85$)

1. Employees receive extensive technical training for their jobs.
2. Employees are strongly encouraged to pursue continuing education from colleges and universities.
3. We provide extensive reimbursement for attending conferences and seminars.
4. We provide extensive reimbursement for continuing university education.
5. We provide reimbursement for subscriptions to technical journals or association memberships.
6. Performance appraisals are used primarily to set goals for personal development.
7. Performance appraisals are used to plan skill development and training.
8. Performance appraisals are used to plan skill development and training for future advancement in the company.

Commitment-Building HR Practices ($\infty = .78$)

1. Employees are made aware of internal promotion opportunities.
2. Internal candidates are given consideration over external candidates for job openings.
3. Shares of stock are available to all core employees through a stock purchase plan.
4. Shares of stock are available to all core employees through a stock option plan.
5. Employee bonus or incentive plans are based primarily on the performance of the organization.
6. Employee bonus or incentive plans are based on the performance of the work group.
7. The company provides incentives for new ideas.
8. We allow employees to wear casual clothing at work.
9. We allow employees to work flexible hours.

Networking Practices ($\infty = .84$)

1. Employees frequently work in cross-functional teams.
2. Employees primarily work in a team-based environment.
3. We use job rotation to expand the skills of employees.
4. We pair new employees with experienced employees.
5. We use an official mentoring system for the development of employees.
6. We sponsor company social events for employees to get to know one another.
7. This company frequently sponsors events to celebrate business successes.
8. We sponsor outside activities for employees (e.g., sports teams, events).