

Knowledge Exchange and Combination: The Role of Human Resource Practices in the Performance of High-Technology Firms

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KNOWLEDGE EXCHANGE AND COMBINATION: THE ROLE OF HUMAN RESOURCE PRACTICES IN THE PERFORMANCE OF HIGH-TECHNOLOGY FIRMS

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In this study, we developed and tested a theory of how human resource practices affect the organizational social climate conditions that facilitate knowledge exchange and combination and resultant firm performance. A field study of 136 technology companies showed that commitment-based human resource practices were positively related to the organizational social climates of trust, cooperation, and shared codes and language. In turn, these measures of a firm's social climate were related to the firm's capability to exchange and combine knowledge, a relationship that predicted firm revenue from new products and services and firm sales growth.

There is a widely held belief that an organization's survival and success are at least partially dependent on the effort, behaviors, and interactions of employees as they carry out the mission and strategy of the firm (Wright & McMahan, 1992). Strategic human resource scholars have argued that companies can effectively influence the interactions, behaviors, and motivation of employees through different human resource (HR) practices (Huselid, 1995; Wright, Dunford, & Snell, 2001). In this regard, two HR practice alternatives have emerged in the literature: transaction-based HR practices, which emphasize individual short-term exchange relationships, and commitment-based HR practices, which focus on mutual, long-term exchange relationships (Arthur, 1992; Tsui, Pearce, Porter, & Hite, 1995). Thus, a central issue that companies must resolve involves choosing and implementing the HR practices that best facilitate organizational success.

To that end, a growing body of evidence suggests that commitment-based HR practices are more pos-

itively related to firm performance than are practices that are transaction-based. For example, researchers have found a positive relationship between more commitment-based HR practices and firm performance in manufacturing firms (Arthur, 1992, 1994; MacDuffie, 1995; Youndt, Snell, Dean, & Lepak, 1996), in service organizations (Batt, 2002), and in a diversified sample of businesses (Huselid, 1995). Although the specific HR practices applied vary across studies, companies following a commitment-based approach implement practices that collectively demonstrate a long-term investment in their employees (Tsui, Pearce, Porter, & Tripoli, 1997). The exact individual HR practices that create a commitment-based environment differ across companies and studies, but they generally include a combination of employee selection practices that focus on creating internal labor markets and assessing fit to the company rather than on specific job requirements; compensation practices that focus employee motivation on group and organizational performance indicators; and training programs and performance appraisals that emphasize long-term growth, team building, and the development of firm-specific knowledge (Arthur, 1992; Tsui et al., 1997).

Although commitment-based HR practices appear to be related to firm performance, little research has empirically explored the causal mechanisms through which these HR practices lead to greater firm performance (Becker & Gerhart, 1996; Wright et al., 2001). The literature suggests that commitment-based HR practices create an organizational social climate that motivates employees to

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act in the best interests of their firm rather than only in their individual self-interest (Rousseau, 1995; Tsui et al., 1995). This view closely matches the perspective of research on strategic human resource management (SHRM), which suggests that commitment-based HR practices affect firm performance by creating an organizational environment that elicits employee behaviors and capabilities that contribute to firm competitive advantage (Bowen & Ostroff, 2004; Collins & Clark, 2003). Some initial empirical research suggests that positive employee relations affect firm performance by creating positive employee attitudes (Fulmer, Gerhart, & Scott, 2003), yet there is a need to examine how commitment-based HR practices influence the broader social context, such as a firm's social climate. Our first goal was to develop and test theory about how commitment-based HR practices affect the organizational social climate that motivates employees to work together to generate new knowledge and subsequent firm performance.

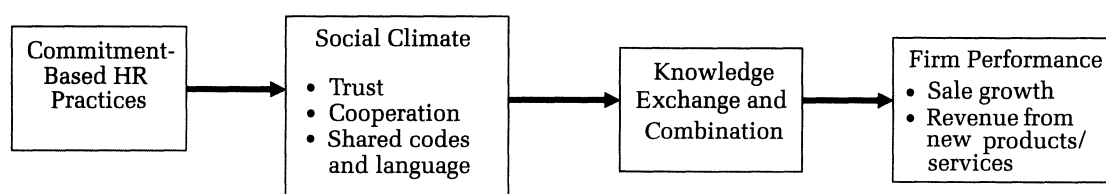
Researchers exploring this mediated model must be careful in identifying the social climates important for the companies in their samples, because the social climate conditions that drive performance will likely vary with the industry conditions those companies face (Collins & Clark, 2003; Fulmer et al., 2003). Further, previous firm-level HR studies have focused on companies facing relatively stable business conditions and technologies (e.g., auto manufacturing plants, steel mini-mills), but these studies provide little guidance on the role of commitment-based HR practices in firms facing more dynamic environments. Importantly, firms in rapidly changing industries derive their primary competitive advantage through the ability of their employees to create and manage knowledge (Bettis & Hitt, 1995; Grant, 1996). Therefore, there is a need to understand how commitment-based HR systems can facilitate the exchange and combination of ideas and knowledge among employees (Smith, Collins, & Clark, 2005). Our second goal was to examine

how commitment-based HR practices affect firm performance in rapidly changing environments.

Most research on commitment-based HR practices has focused on lower-level workers (e.g., call center operators, manufacturing line employees), ignoring how these practices affect other types of employees (Lepak & Snell, 1999). This is an important issue because firms are composed of multiple types of employees who are managed differently and who impact performance in different ways (Lepak & Snell, 1999). All employees may create some value, but companies in dynamic industries may be especially dependent on the ability of knowledge workers, such as scientists and engineers, to exchange and combine information in new ways (Grant, 1996; Huber, 2004). For example, Appleyard and Brown (2001) found evidence that engineers played a greater role in the success of semiconductor firms than did line employees. Our third objective was to examine how commitment-based HR practices influence key knowledge workers, those who are likely to have the greatest impact on firm performance through knowledge exchange and combination.

To foreshadow our arguments and highlight our contribution, we elaborate a model of how commitment-based HR practices affect knowledge exchange and combination and ensuing firm performance through organizational social climates. Figure 1 contains this model. We begin by defining commitment-based HR practices and theoretically linking them to the organizational social climate factors that may drive knowledge exchange and combination. Next, we draw on theory from the knowledge creation literature and the knowledge-based view of the firm to theoretically connect organizational social climates to firm performance through their effects on knowledge exchange and combination. Finally, we extend the application of commitment-based practices to a new context and type of worker by examining the effects of these HR practices on a sample of knowledge workers from 136 high-technology firms.

FIGURE 1
Model Linking Commitment-Based HR Practices to Firm Performance



THEORY AND HYPOTHESES

The Strategic View of Human Resource Management

The SHRM approach differs from prior research in HR in that strategic researchers examine the effects of HR practices on outcomes at the organizational level of analysis, such as firm productivity or growth (Becker & Huselid, 1998; Wright et al., 2001). Within this literature, a consensus exists that companies can manage the employer-employee relationship and motivate employees through HR practices with a commitment orientation (Rousseau, 1995; Tsui et al., 1997). This commitment-based approach emphasizes the implementation of a combination of HR practices that work together to motivate employees to contribute high levels of discretionary behaviors by aligning their interests with those of the organizations and creating a mutually reinforcing high-investment employer-employee relationship (Arthur, 1992; Tsui et al., 1997).

Practices that an organization may adopt to create this type of employment relationship include recruitment and selection to create growth opportunities for employees through internal labor markets and identifying external candidates who are a fit to the company (Delery & Doty, 1996; Tsui et al., 1997); organization- or team-based compensation designed to increase knowledge sharing and commitment to the organization (Delaney & Huselid, 1996; Delery & Doty, 1996); and training and performance appraisal that enable employee growth and development and build firm-specific knowledge (Arthur, 1992; Youndt et al., 1996). By demonstrating high investment in employees, commitment-based HR practices increase employees' motivations to contribute the behaviors and acquire the firm-specific knowledge required to support their company's strategy (Rousseau, 1995).

Although a growing body of studies has provided evidence of a relationship between commitment-based HR practices and firm performance, much less is known about the mechanisms through which these HR practices affect firm performance (Wright et al., 2001). However, researchers have begun to argue that commitment-based HR practices don't directly impact performance, but instead foster social climates that facilitate the development of employee-based capabilities—such as the ability to combine and exchange information to create new knowledge—that in turn create competitive advantage (Bowen & Ostroff, 2004; Collins & Clark, 2003). Recent empirical work also seems to support the notion that HR practices affect firm

performance through employee attitudes (Fulmer et al., 2003) and capabilities (Collins & Clark, 2003). Building on this work, we examine how commitment-based HR practices facilitate the development of firmwide social climate that encourages the exchange and combination of knowledge among knowledge workers.

As competition among technology-based firms has increased, the source of competitive advantage in these firms has migrated from tangible resources and market power to knowledge and know-how (Grant, 1996; Huber, 2004). In addition, the ability to create new knowledge is a firm-specific resource that can yield new revenue-producing opportunities and enable firms to respond effectively to rapidly shifting environments (DeCarolis & Deeds, 1999; Grant, 1996). Given the importance of knowledge creation, scholars have begun to study how firms can develop this unique competency (Argote, McEvily, & Reagans, 2003). Nahapiet and Ghoshal (1998) argued that new knowledge is created within organizations through the process of exchange and combination among employees. Implicit in this argument is the notion that exchange and combination create new knowledge by connecting previously unconnected ideas and knowledge or recombining previously connected ideas and knowledge in novel ways (Kogut & Zander, 1992; Nahapiet & Ghoshal, 1998).

Further, the social climate of a firm—employees' shared beliefs regarding the norms and values that govern interactions among them as they carry out their jobs (Ashkanasy, Wilderom, & Peterson, 2000)—can affect employees' abilities, motivations, and opportunities to exchange and combine their knowledge (Argote et al., 2003; Kogut & Zander, 1992). In particular, relational aspects of organizational social climate, such as trust, cooperation, and shared language, are key mechanisms that enable employees to exchange and recombine knowledge (Nahapiet & Ghoshal, 1998; Smith et al., 2005). Creating a social climate that facilitates knowledge sharing may be particularly crucial for high-technology companies as their employees often see knowledge as a source of power and job security, a perception that makes them unwilling to share tacit knowledge with other employees (Davenport & Prusak, 1998). In particular, researchers have argued that firm social climate may encourage employees to focus on the larger community of the organization rather than on their own best interests, thus facilitating knowledge exchange and combination (e.g., Nahapiet & Ghoshal, 1998; Reagans & McEvily, 2003).

Commitment-Based HR Practices and Organization Social Climate

We were particularly interested in identifying how commitment-based HR practices affect the social climates that facilitate or restrict knowledge exchange between knowledge workers. Following Ashkanasy et al. (2000) and Smith et al. (2005), we defined *social climate* as the collective set of norms, values, and beliefs that express employees' views of how they interact with one another while carrying out tasks for their firm. Below, we argue that commitment-based HR selection, training and development, and incentive practices will affect social climates for trust, cooperation, and shared codes and language. In turn, we expect that a social climate for trust, cooperation, and shared codes and language will facilitate knowledge exchange and combination.

Trust. Mayer, Davis, and Schoorman defined trust as "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" (1995: 712). They suggested that trust is rooted in three interrelated components: ability (belief that the other is capable and skilled), benevolence (desire to do good for the other), and integrity (belief that the other is motivated by principles of fairness). Although trust can vary according to individual differences in the propensity to support and believe in others (Mayer et al., 1995), we contend that that a social climate of trust may be influenced by a firm's HR practices.

Commitment-based HR practices foster higher trust between employees by implementing group-based incentives and providing training and development opportunities for greater communication and interaction. More specifically, compensation based on firm or group outcomes should be effective in aligning employees' actions with organizational goals (Milkovich, 1987) and ensuring that people work together (Lawler, Mohrman, & Ledford, 1995). Over time, group- or organization-based incentives may increase the perceived integrity and trust of others as employees develop norms that recognize contributions and impose sanctions for social loafing (Leana & Van Buren, 1999). Employees are also more likely to trust one another if they have interacted with or had the chance to work with one another (Whitener, Brodt, Korsgaard, & Werner, 1998). Importantly, commitment-based practices such as internal promotion policies, job rotation, and team-based work design increase the chances for such exposure. In addition,

performance appraisals that focus on employee development provide opportunities for employees to be seen by others as capable.

Cooperation. Following Wagner (1995), we defined a social climate for cooperation as the organizational norms that emphasize personal effort toward group outcomes or tasks as opposed to individual outcomes. As with trust, we expected commitment-based HR practices to increase the norms for cooperation between knowledge workers. Specifically, team-based work design and organization-based compensation and rewards encourage employees to focus on organizational and team accomplishments, thus increasing the prevalence of shared values and goals (Arthur, 1992; Tsui et al., 1997). When employees share a common purpose and goals, they are more likely to cooperate with one another to achieve those goals (Wagner, 1995).

Shared codes and language. Shared codes and language comprise a common set of terms, symbols, and understandings that allow individuals to communicate effectively with one another (Nahapiet & Ghoshal, 1998). As with other aspects of social climate, we expected commitment-based HR practices to facilitate and support shared codes and language among knowledge workers. Internal development opportunities such as cross-training, promotion from within, and mentoring facilitate the development of shared language among employees by exposing them to the jargon and perspectives used by different functional areas and levels of their firm (Noe, 1999). Individuals are also more willing to develop firm-specific skills such as shared language when they receive reciprocal investment from the firm (Rousseau, 1995). Practices such as investment in training and development, company-wide social events, and internal promotion opportunities demonstrate a company's investment in employees, increasing individuals' willingness to develop firm-specific skills (MacDuffie, 1995) as well as increasing the degree of understanding among employee groups.

Hypothesis 1. Commitment-based HR practices are positively related to an organization's social climates for trust, cooperation, and shared codes and language.

Social Climate, Knowledge Exchange and Combination, and Firm Performance

The ability to create new knowledge, which enables firms both to innovate and to outperform their rivals in dynamic environments (Grant, 1996; Kogut & Zander, 1992), results from the collective

ability of employees to exchange and combine knowledge (Nahapiet & Ghoshal, 1998). Further, characteristics of firm social environment facilitate such exchange and combination (Kogut & Zander, 1992; Nahapiet & Ghoshal, 1998). Below, we outline the specific relationships between organizational social climate, knowledge exchange and combination, and firm performance that we tested in this study.

A social climate of trust is widely seen as essential for increasing interaction and the likelihood of information exchange between individuals (Mayer et al., 1995; Nahapiet & Ghoshal, 1998). For example, trust reflects a trustor's belief that a trustee will not act opportunistically (Bradach & Eccles, 1989), increasing their willingness to share valuable or proprietary information. Trust also enhances the likelihood of exchange of information and ideas because trustworthy social conditions enhance actors' beliefs that a current exchange will lead to later reciprocation (Coleman, 1990). High levels of trust also increase employees' tendencies to seek and offer help, increasing the chances for exchange (Jones & George, 1998). A social climate of trust should promote the exchange of valuable ideas between core knowledge workers that will, in turn, lead to greater innovation and firm growth. In contrast, when trust among employees is low, individuals will be cautious about exchanging information and ideas with one another, and firm performance will suffer.

Nahapiet and Ghoshal (1998) suggested that cooperation between employees is a key aspect of firm social climate that drives knowledge exchange and combination processes. A climate for cooperation limits competition between employees and increases their willingness to share critical information with one another (Szulanski, 1996). Research also suggests that creativity is enhanced when the level of cooperation between members of a team is high (Amabile, 1996; Tushman & O'Reilly, 1997). Therefore, a strong climate for cooperation between knowledge workers will positively affect firm performance by increasing the exchange of valuable and unique information among them.

Although a climate of trust and cooperation may increase the likelihood that exchange will take place, shared codes and language facilitate both access to information and integration of exchanged knowledge. For example, differences in language reduce the likelihood of exchange between individuals (Boland & Tenkasi, 1998; Nahapiet & Ghoshal, 1998). More importantly, from the perspective of absorptive capacity, a degree of shared knowledge or understanding is essential for individuals to comprehend and integrate new knowledge that is

acquired from exchange with other employees (Cohen & Levinthal, 1990; Hansen, 2002). A climate for shared codes and language provides a common base of understanding through which individuals with disparate experience, knowledge, and backgrounds can transfer and integrate new ideas (Szulanski, 1996). Therefore, a greater level of shared codes and language between knowledge workers will positively affect the performance of high-technology firms by facilitating knowledge exchange and combination among knowledge workers.

Hypothesis 2. Organizational social climates for trust, cooperation, and shared codes and language are positively related to firm performance (revenue from new products and services and one-year sales growth) through their effects on knowledge exchange and combination.

The Mediated Effect of Commitment-Based HR Practices on Firm Performance

As discussed above, one assumption underlying research on SHRM is that commitment-based HR practices do not affect performance directly. Rather, these practices lead to higher performance when they develop the organizational social climate and employee-based capabilities that are important for firm performance (Bowen & Ostroff, 2004; Collins & Clark, 2003). We argue that commitment-based HR practices affect firm performance through their effects on organizational social climates and on knowledge exchange and combination among knowledge workers. Commitment-based HR practices, however, are likely to affect firm performance in other ways as well (Delery & Doty, 1996). For example, Huselid (1995) argued that HR practices affect firm performance by attracting or developing higher levels of human capital and employee motivation. Thus, we predict that organizational social climate and knowledge exchange and combination will only partially mediate the relationship between HR practices and firm performance.

Hypothesis 3. Commitment-based HR practices partially affect employee knowledge exchange and combination and subsequent firm performance through organizational social climates for trust, cooperation, and shared codes and language.

METHODS

Overview of the Research Process

During a ten-month period in 1999 and 2000, we gathered data from knowledge-intensive firms in

two regions of the United States characterized as high-technology hot spots. To test our hypotheses, we measured four sets of constructs: commitment-based HR practices, organizational social climates, organizational knowledge exchange and combination, and firm performance. We limited problems associated with common method variance by collecting measures of the independent, mediating, and dependent variables from different data sources. Specifically, we used surveys of human resource managers to assess commitment-based HR practices; surveys of core knowledge workers to estimate social climate and knowledge exchange and combination; and interviews with CEOs and public corporate records to measure firm performance. Further, we collected measures of firm performance for the one-year period 2000–01 after collecting the data on the independent variables.

Sample and Research Procedures

We included only high-technology firms, defined as companies that “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 firms employing more than 100 employees to focus on firms that were most likely to have formally established HR systems (Huselid, 1995). Finally, we included firms in our study only if they had publicly available financial information on sales growth. As part of the study, we conducted interviews with the CEOs of participating firms to ensure that their companies conformed to these criteria.

Using two business publications that profiled regional high-technology firms, we compiled a list of 513 companies that met the above criteria. One publication profiled technology firms in the Washington, DC, region, and one profiled technology firms in Austin, Texas. We dropped 116 companies (23%) from the original sample because they were either no longer in business, had diversified to acquire nontechnology businesses, or had been acquired by other firms. Of the remaining 397 firms, 143 agreed to participate in the study. Missing data on some variables reduced the sample to 136 companies (a 34 percent participation rate). Organizations that agreed to participate did not differ from nonparticipating firms in reported sales ($t_{211} = 1.25$, n.s.) or number of employees ($t_{211} = 1.53$, n.s.). Company size had a mean of 502 employees, with a standard deviation of 461, and it ranged

from 110 to 1,360 employees. Our final sample of companies was drawn from six high-technology industries: software, telecommunications, information technology consulting, computer electronics, pharmaceuticals, and semiconductors.

During an interview, we asked the CEO of each participating company to identify a senior HR manager and up to 15 core knowledge workers, defined as employees “critical for creating new knowledge or developing innovations within your organization.” To increase participation within firms, we included signed endorsements from their CEOs with each survey sent to employees. One human resource manager participated from each company, for an overall internal participation rate of 100 percent. An average of 7.72 core knowledge workers completed surveys at each company; the range was 3 to 15 respondents, and the overall internal participation rate was 61 percent. These respondents held the following jobs: 47 percent were engineers, 21 percent were software developers, 17 percent were scientists, 9 percent were consultants, and 6 percent were project managers, suggesting that our sample of respondents held jobs directly related to knowledge creation.

Variables

Commitment-based HR practices. Procedures used by Delery (1998) and by MacDuffie (1995) were used in the theoretical development of our measure of commitment-based HR practices from a set of commitment-based HR practices focused on training and development, compensation, and selection practice items. We adapted items from previous research or developed them through interviews with HR managers and CEOs of high-technology companies to capture practices specific to managing knowledge workers in technology companies. Specifically, we adapted items from Delery and Doty (1996), who assessed an external market-based approach versus an internal commitment-based approach, and from Youndt and coauthors (1996), who assessed a transactional approach versus a human-capital-enhancing (i.e., commitment-based approach). We asked three HR managers from high-tech firms similar to those in our sample to assess the wording and appropriateness of the items that we developed. The HR manager at each participating company was asked to rate the extent to which he or she agreed (1 = “strongly disagree,” 5 = “strongly agree”) that the company used various HR practices to manage knowledge workers similar to those identified by the CEO of the company.

Overall, we used 16 items representing three sub-

dimensions to measure commitment-based HR practices: internal labor markets and selection based on fit to the company; group- and organization-based incentives; and training programs and performance appraisals based on long-term growth, team building, and development of firm-specific knowledge. Appendix A gives our specific items. Although the 16 items reflected three subdimensions of commitment-based HR practices, we found support for a single commitment-based HR factor, which we labeled "commitment-based HR practices." More specifically, we conducted a principal components factor analysis with varimax rotation and found that all 16 items loaded on a single factor with an eigenvalue of 9.51. Second, we found that the scale also showed good reliability ($\alpha = .87$). A high score on this factor reflects a high use of commitment-based HR practices to manage the employer-employee relationship for key knowledge workers; a low score reflects a low use of commitment-based HR practices.

Finally, to provide additional evidence of construct validity, we examined the relationship between our measure of HR practices and indicators of a mutually committed employer-employee relationship. Specifically, a company that has created an employment relationship characterized by mutual investment on the parts of company and employees should have lower turnover and higher tenure among employees than a company that has created a relationship based on a short-term outlook and economic exchange. We found that commitment-based HR practices were negatively correlated with employee turnover ($r = -.57, p < .01$), measured as the number of employees that had voluntarily left in the past year, as reported by the HR managers. Further, we found that commitment-based HR practices were positively correlated with employee tenure ($r = .63, p < .01$), measured as average years of company work experience, collected from the knowledge worker surveys.

Organizational social climate. We collected measures of social climate through surveys of knowledge workers. For each set of items below, knowledge workers were asked to assess the degree to which they agreed (1 = "strongly disagree," 5 = "strongly agree") with each statement. Because we were interested in firm-level effects, we worded all items on the knowledge worker surveys to reflect organization-level constructs. In addition, we examined intraclass correlations (ICCs) before aggregating these measures to the firm level (Bliese, 1998).

Trust. We measured climate for trust with a 12-item scale adapted from Mayer and Davis (1999). The scale included 4 items for each of the three

dimensions of trust identified by Mayer et al. (1995): ability, benevolence, and integrity. We measured ability with 4 items assessing the degree to which respondents believed that other knowledge workers were capable and skilled (e.g., "Our employees feel confident about each others' skills"). We measured benevolence with 4 items assessing the extent to which respondents felt knowledge workers in the company wanted to do good toward each other (e.g., "The employees in this organization will go out of their way to help each other with work"). We measured integrity with 4 items assessing the extent to which respondents felt knowledge workers behaved fairly with each other (e.g., "Employees in this organization try hard to be fair in their dealings with one another"). The 12-item scale showed good reliability ($\alpha = .91$). ICCs for the aggregated index (ICC[1] = .24, ICC[2] = .72) exceeded levels suggested by Bliese (1998); therefore, we averaged responses for the knowledge workers in each firm to create an aggregated measure.

Cooperation. We measured the climate for cooperation with a six-item scale adapted from Chatman and Flynn (2001). Sample items included, "There is little collaboration between employees at this company" (reverse-scored), "Employees here are willing to sacrifice their self-interests for the benefit of the group," and "There is a high level of sharing between employees in this organization." The scale demonstrated high reliability ($\alpha = .88$). ICCs for the aggregated index (ICC[1] = .26, ICC[2] = .74) exceeded levels suggested by Bliese (1998); therefore, we averaged the responses for knowledge workers within each firm to estimate cooperation.

Shared codes and language. To measure the climate for shared codes and language, we developed five items based on Nahapiet and Ghoshal (1997). Sample items included, "Employees are always on the same page when they talk about work" and "Employees in this company have trouble understanding each other when working together on a project" (reverse-scored). The scale demonstrated high reliability ($\alpha = .84$). ICCs for the aggregated index (ICC[1] = .26, ICC[2] = .70) exceeded levels suggested by Bliese (1998); therefore, we averaged the responses across knowledge workers within each firm to estimate the extent of the shared codes and language between knowledge workers.

Knowledge exchange/combination. As noted above, the likelihood of knowledge exchange and combination among employees is dependent upon employee motivation and ability (Argote et al., 2003; Nahapiet & Ghoshal, 1998). Therefore, we measured knowledge exchange/combination with an eight-item scale, given in Appendix B, that assessed knowledge workers' beliefs that exchange

and combination would yield personal or organizational value (motivation) and the extent to which they believed that employees could exchange and combine information (ability). The Appendix lists specific items. These items were developed in several brainstorming sessions and were prescreened for wording and appropriateness with MBA students and current managers who had high-tech work experience. We asked knowledge workers to assess the extent to which they agreed with each statement, using the same scale noted above. Scale reliability ($\alpha = .91$) and ICC values for the aggregated index (ICC[1] = .24, ICC[2] = .72) were good (Bliese, 1998); therefore, we averaged responses for respondents within each firm to estimate knowledge exchange/combination.

We collected the measures of organizational social climate and knowledge exchange and combination through surveys of knowledge workers; therefore, we used confirmatory factor analysis to test for construct distinctiveness. We used individual-level data in these tests in order to have enough observations for data stability. Chi-square difference tests indicated that a four-factor model (climates for trust, cooperation, shared codes and language, and knowledge exchange/combination) showed reasonable fit to the data (model $\chi^2 = 1,614.51$, $df = 224$; CFI = .88, IFI = .88; LISREL GFI = .86). Further, the chi-square difference tests indicated that the four-factor model was a better fit to the data than (1) a one-factor model ($\Delta\chi^2 = 1,666.68$, $df = 6$, $p < .01$) or (2) a two-factor model in which the organizational social climate items were one factor and knowledge exchange and combination items were a second factor ($\Delta\chi^2 = 1,232.41$, $df = 5$, $p < .01$).

Firm performance. We measured firm performance as both revenue from new products and services and one-year sales growth, because these are good indicators of the extent to which high-technology firms have been able to innovate and create new knowledge. We collected our measure of revenue from new products or services through a follow-up survey sent to each CEO one year after the original data collection. We asked each CEO to identify the percentage of sales for the past year that was driven by the sales of products or services released in the that year. We collected our measure of one-year sales growth from COMPUSTAT for the year following the date of collection of HR manager and knowledge worker surveys.

Control variables. Because firms may be more able to innovate when they have greater resources (Autio, Sapienza, & Almeida, 2000), we controlled for firm size using a natural logarithmic transformation of the number of full-time employees. We also controlled for the number of office locations, because employees may be less willing or able to share knowledge when they are more geographically dispersed. Firms in our sample were drawn from six different high-technology industries that likely face different market conditions. Therefore, we controlled for industry differences with effects coding in the regression analyses (we included five dummy codes, with semiconductors as the omitted industry).

RESULTS

Table 1 reports the means, standard deviations, and correlations of all variables. In general, our results showed significant correlations between de-

TABLE 1
Means, Standard Deviations, Reliabilities, and Correlations^a

Variables	Mean	s.d.	1	2	3	4	5	6	7	8
1. One-year sales growth	0.28	0.32								
2. Revenue from new products and services	0.36	0.26	.68**							
3. Knowledge exchange/combination	3.69	0.68	.49**	.54**	(.91)					
4. Climate for trust	3.63	0.63	.38**	.29**	.41**	(.91)				
5. Climate for cooperation	3.70	0.72	.26**	.32**	.43**	.34**	(.88)			
6. Shared codes and language	3.26	0.71	.32**	.26**	.37**	.25**	.28**	(.84)		
7. Commitment HR practices	3.51	0.63	.38**	.39**	.46**	.47**	.50**	.42**	(.87)	
8. Number of employees	501.85	461.33	.06	.01	-.14	.11	.09	.10	.09	
9. Number of locations	4.57	4.01	.00	-.04	-.10	-.09	-.02	-.04	.03	.61**

^a $n = 136$.

** $p < .01$

pendent and independent variables and limited collinearity between our independent variables. Next, we used ordinary least squares regression analysis to test each of our hypotheses. As shown in models 2, 4, and 6 of Table 2, we found that our measure of commitment-based HR was significantly related to a climate of trust ($\beta = .47, p < .01$), cooperation ($\beta = .48, p < .01$), and shared codes and language ($\beta = .43, p < .01$) after controlling for company size, number of locations, and industry. Thus, we found support for Hypothesis 1: commitment-based HR practices were positively related to the organizational social climate conditions that guide knowledge workers' interactions with one another.

We present the regression results with knowledge exchange and combination as the dependent variable in Table 3. First, as shown in model 2 of Table 3, we found that our measure of commitment-based HR was significantly related to knowledge exchange and combination among knowledge workers ($\beta = .48, p < .01$). Next, as shown in model 3 of Table 3, we added the social climate variables (trust, cooperation, and shared codes and language) and found that the relationship between commitment-based HR practices and knowledge exchange/combination was dramatically reduced but still significant ($\beta = .20, p < .05$). In addition, trust ($\beta = .28, p < .01$), cooperation ($\beta = .32, p < .01$), and shared codes and language ($\beta = .21, p < .01$) were all significantly related to knowledge exchange and combination. Overall, we found that the relationship between commitment-based HR practices and

knowledge exchange and combination was reduced by 58 percent when the three social climate variables were added to the regression equation. Thus, we found support for Hypothesis 2: it appeared that organizational climates of trust, cooperation, and shared codes and language were associated with higher levels of knowledge exchange/combination among knowledge workers. Further, commitment-based HR was significantly related to knowledge exchange and combination, but this relationship appeared to be partially mediated through organizational social climates.

Next, we examined the combined mediating effects of social climates and knowledge exchange and combination on the relationship between commitment-based HR and firm performance (see Table 4). Following Baron and Kenny's (1986) three-step procedure, we first examined the relationships between the independent and dependent variables. As shown in models 2 and 6, our measure of commitment-based HR practices was significantly related to revenue from new products and services ($\beta = .41, p < .01$) and sales growth ($\beta = .37, p < .01$). In the second of the three steps, we found significant relationships between the commitment-based HR practices and firm social climates (trust, cooperation, and shared codes and language) and knowledge exchange and combination (see above).

Finally, in the third step of the procedure, we examined changes in the effect of commitment-based HR practices when social climate and knowledge exchange and combination variables were added to the regressions predicting firm perfor-

TABLE 2
Results of Regression Analyses Predicting Social Climate^a

Variables	Trust, Model 1	Trust, Model 2	Cooperation, Model 3	Cooperation, Model 4	Shared Codes and Language, Model 5	Shared Codes and Language, Model 6
Number of employees ^b	.07	.02	.16*	.10	.14	.09
Number of locations	-.17*	-.16*	-.12	-.11	-.08	-.08
Industry 1	.09	.15	.09	.11	.05	.12
Industry 2	-.06	-.12	-.09	-.13	-.14	-.13
Industry 3	-.09	-.13	-.11	-.15	.06	.11
Industry 4	.04	.01	.06	-.02	-.08	-.03
Industry 5	.03	-.02	.09	.09	-.06	-.02
Commitment-based HR system		.47**		.48**		.43**
<i>R</i> ²	.04	.25	.04	.28	.02	.21
ΔR^2	.04	.20	.04	.26	.02	.19
ΔF	1.34	31.22**	1.44	34.43**	1.01	28.64**

^a Standardized coefficients are shown.

^b Logarithm.

* $p < .05$

** $p < .01$

TABLE 3
Results of Regression Analyses Predicting Knowledge Exchange and Combination^a

Variables	Model 1	Model 2	Model 3
Number of employees ^b	-.10	-.11	-.13
Number of locations	-.03	-.03	.11
Industry 1	.03	.12	.05
Industry 2	-.02	-.09	-.13
Industry 3	-.10	-.11	-.14
Industry 4	.02	.02	-.10
Industry 5	.03	-.06	-.12
Commitment-based HR practices		.48**	.20*
Climate for trust			.28**
Climate for cooperation			.32**
Shared codes and language			.21**
<i>R</i> ²	.01	.24	.35
ΔR^2	.01	.23	.11
ΔF	0.34	25.21**	8.02**

^a Standardized coefficients are shown.

^b Logarithm.

* $p < .05$

** $p < .01$

TABLE 4
Results of Regression Analyses Predicting Firm Performance^a

Variables	Revenue from New Products and Services				One-Year Sales Growth			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Number of employees	.05	.03	-.07	-.11	.09	.06	-.07	-.06
Number of locations	-.07	-.05	-.06	-.02	-.05	-.04	.10	-.02
Industry 1	.11	.08	.09	.10	.03	.09	.07	.09
Industry 2	.05	.03	-.05	.02	.05	.03	-.05	.00
Industry 3	.03	.09	-.04	.03	-.02	.07	-.06	.03
Industry 4	-.04	.04	-.03	-.01	-.07	.04	-.03	-.01
Industry 5	.05	-.01	-.07	-.03	.04	-.01	-.07	-.04
Commitment-based system		.41**	.19*	.10		.37**	.15	.06
Climate for trust			.18*	.09			.29**	.19*
Climate for cooperation			.24**	.13			.18*	.03
Shared codes and language			.21**	.12			.23**	.12
Knowledge exchange/ combination				.46**				.43**
<i>R</i> ²	.01	.14	.21	.29	.01	.13	.19	.24
ΔR^2	.01	.13	.07	.08	.01	.11	.06	.05
<i>F</i>	0.92	16.12**	4.92**	8.27**	0.83	12.56**	3.74**	4.77**

^a Standardized coefficients are shown.

^b Logarithm.

* $p < .05$

** $p < .01$

mance. Our results showed that the relationship between commitment-based HR practices and revenue from new products and services was lower but still significant when the three climate variables were added to the regression equation (see

model 3) and was no longer significant when knowledge exchange/combination was added (see model 4). From the change in the beta coefficient representing the effect of commitment-based HR practices on revenue from new products and ser-

vices, it appears that approximately 54 percent of this relationship was explained by the social climate mediators, and an additional 22 percent was explained by the addition of knowledge exchange/combination. As shown in models 7 and 8, the effect of commitment-based HR on sales growth dropped to nonsignificance when social climate was added to the regression and dropped further when knowledge exchange/combination was added. The change in the beta representing the effect of commitment-based HR practices on sales growth indicates that approximately 59 percent of this relationship was explained by the social climate mediators, and an additional 22 percent was explained by knowledge exchange/combination. Thus, although there are some residual direct effects, a large proportion of the relationship between commitment-based HR practices and firm performance in our sample seems to be explained by the mediating effects of social climates and knowledge exchange and combination.

The results presented in Table 4 also support our argument that knowledge exchange and combination at least partially mediate the effects of social climates on firm performance. As shown in model 3 of Table 4, climates for trust ($\beta = .18, p < .05$), cooperation ($\beta = .24, p < .01$), and shared codes and language ($\beta = .21, p < .01$) were all significantly related to revenue from new products and services. Next, the effects of all three social climate variables dropped to nonsignificance when knowledge exchange and combination were added to the regression predicting revenue from new products and services (see model 4). When examining one-year sales growth (see model 7), we again found that effects of all three climate variables were significant (trust, $\beta = .29, p < .01$; cooperation, $\beta = .18, p < .05$; shared codes and language, $\beta = .23, p < .01$). Again, cooperation and shared codes and language were no longer significantly related to sales growth when knowledge exchange/combination was added to the equation (see model 8). The relationship between trust and one-year sales growth was reduced but still significant at the .05 level. Overall, knowledge exchange and combination explained between 36 and 83 percent of the relationships between social climate conditions and firm performance. Thus, our results suggest that knowledge exchange/combination at least partially mediates the effects of cooperation and shared codes and language on firm performance.

DISCUSSION

The purpose of this research was to elaborate and test a more detailed model of how commitment-

based HR practices affect knowledge creation and firm performance through organizational social climate. We developed this model by first defining commitment-based HR practices in terms of selection, training and development, and pay incentives. We then conceptually and empirically connected these practices to the organizational social climate conditions that drive knowledge exchange and combination among knowledge workers. Importantly, we also formulated and tested theory from the knowledge creation literature that connects social climate conditions to firm performance through their effect on knowledge exchange and combination. Finally, we extended the literature on SHRM to a new context and new set of employees by examining the effects of commitment-based HR practices on a sample of knowledge workers from high-technology firms.

Importantly, the effects we discovered are also meaningful from a practical and financial standpoint. In particular, our results showed that a one-standard-deviation increase in commitment-based HR practices yields a 16.9 percent increase in sales from new products and services and an 18.8 percent growth in sales. Further, although it is necessary to consider mediating links in order to understand the impact of HR practices on firm performance (Becker & Gerhart, 1996), prior studies have rarely specified or tested specific HR practices and underlying organizational capabilities to establish these links (Wright et al., 2001). Our study represents an initial step in this direction. Specifically, we found that commitment-based HR practices were indirectly related to firm performance through their effects on organizational social climate and knowledge exchange and combination. Thus, our findings support the argument that researchers must explore mediating firm capabilities to fully understand the role of HR practices on firm performance. In addition, it may be desirable for future research to focus on firms facing similar environments rather than on firms with diverse environments, because within- rather than cross-industry studies will better allow researchers to identify the firm capabilities necessary for success.

We were surprised that our mediators explained such a large proportion of the effects of commitment-based HR practices and firm performance. As noted above, the addition of the social climate variables and of knowledge exchange/combination explained approximately 76 percent of the relationship between commitment-based HR and revenue from new products and services and 84 percent of the relationship between commitment-based HR practices and sales growth, leaving few remaining effects of commitment-based HR to be explained by

the other potential mediators suggested in the literature. For example, researchers have speculated that commitment-based practices also affect firm performance through their effects on human capital and skills development (Arthur, 1992; MacDuffie, 1995). It is possible that the social conditions governing employee motivations to interact and share knowledge may have a stronger effect on innovation-oriented measures of performance than does the accumulation of individual human capital across knowledge workers. For example, all high-technology firms, independent of their philosophy regarding how to manage the employer-employee relationship, may seek to attract employees who are high in human capital; however, companies may optimally gain from that higher level of human capital only by motivating employees to use that knowledge for the benefit of the firms through HR approaches that create relational employer-employee exchanges.

Perhaps most importantly, our findings provide initial evidence that commitment-based HR practices enable firms to create social environments that are conducive to knowledge exchange and combination. Specifically, firms that employ commitment-based HR practices are associated with organizational climates containing higher levels of trust, cooperation, and shared codes and language among knowledge workers. Further, the practices that we included are a general representation of commitment-based HR practices, not an exhaustive set. Future research should examine a broader set of commitment HR practices and also examine the extent to which such practices need to be internally consistent and reinforcing to maintain a social climate for knowledge exchange and combination.

It is important to note that, although it was greatly reduced, the relationship between commitment-based HR practices and knowledge exchange and combination was still significant after the social climate variables were entered into the regression equation. These HR practices may have direct effects on knowledge exchange and combination, but it is more likely that they affect other aspects of firms that influence the exchange and combination process and were unmeasured in this study. For example, research on knowledge and the knowledge-based view of the firm suggests that factors such as the structural networks between employees (Nahapiet & Ghoshal, 1998; Reagans & McEvily, 2003) and the overall level of human capital in a firm (Smith et al., 2005) may also affect knowledge exchange and combination. Therefore, researchers should begin to explore the effects of commitment-based HR practices on these other drivers of knowledge exchange and combination so as to obtain a

complete explanation of how commitment-based HR practices influence performance.

Our research also supported the argument that organizational social climates are important for performance in high-technology firms through their effects on knowledge exchange and combination. In particular, our results indicated that climates of trust, cooperation, and shared codes and language were all significantly related to revenue from new products and services and sales growth, and these relationships were mediated by the level of knowledge exchange and combination among knowledge workers. This finding supports the public goods argument surrounding social capital in the literature (Coleman, 1990) and suggests that the performance of high-technology firms benefits when they can create social climate conditions of trust, cooperation, and shared codes and language.

We were somewhat surprised, however, that the relationships between the social climate variables were only partially mediated through employee knowledge exchange and combination. It is likely that climates of trust, cooperation, and shared codes and language are strategic variables yielding other firm-level performance benefits beyond knowledge creation. For example, social climates that facilitate high levels of trust, cooperation, and shared language may allow employees to put forth greater effort, increase the efficiency of interactions between employees, and facilitate greater risk taking and experimentation.

As with most research, our results have several limitations. First, unmeasured exogenous variables may affect the relationships we studied. For example, other organizing principles (e.g., organizational structure, leadership) that we did not study may affect firms' social climates; therefore, in future research measures of commitment-based HR practices and other important organizational factors should be simultaneously collected as a means to determine the extent to which HR practices affect the social conditions of firms over and above these other factors. We also did not control for other potential mediators that may explain the relationship between HR practices and firm performance. Future research should look at other variables, such as structural networks, human capital, and team processes, that may also explain the HR-firm performance relationship.

Second, we collected data on social conditions and on knowledge exchange and combination from a subset of knowledge workers in each firm; thus, our measures could only estimate social climates within the larger group of knowledge workers. However, ICC statistics for our social climate variables did indicate a high degree of agreement

among the respondents in each company, suggesting that our results would likely be the same even with larger samples of employees from each firm. Still, researchers may wish to explore the extent to which commitment-based HR practices have similar effects on all the employees to which they are applied.

Third, we followed a “best-practices approach” to studying commitment-based HR, testing whether companies whose approach to HR was based on high commitment generally were higher on our social climate variables and firm performance than were companies whose approach was based on low commitment. Even though our findings suggested that companies following a commitment-based approach generally outperformed those not following a commitment-based approach, we did not examine whether moderating conditions limited the positive impact of commitment-based HR practices. Future research should look at potential moderators of the relationships between these HR practices and organizational social climate, knowledge exchange and combination, and firm performance to determine what types of high-technology companies are the most likely to benefit from adopting a commitment-based approach to managing their knowledge workers. It would also be interesting to examine the conditions under which HR practices that are not commitment based have positive effects on performance. Further, we were unable to determine if the companies that scored low on commitment-based HR practices were following an alternative approach to managing the employer-employee relationship for key knowledge workers. It is possible that alternative HR strategies that are equally successful for managing key knowledge workers exist (Cappelli, 1999). For example, in their study of high-tech start-ups, Baron, Hannan, and Burton (1999) found evidence that CEOs followed one of five models in their approach to structuring the HR practices that shaped the employer-employee relationship. Sherer and Lee (2002), in their study of law firms, found several very different ways to structure employment relationships for lawyers. Therefore, future research should look to determine if companies implement alternative systems of HR practices to manage key knowledge workers and if those alternative systems are as effective as a commitment-based approach for managing core knowledge workers.

Finally, we collected data regarding commitment-based HR practices from a single source—the top HR manager at each company in our sample. Despite our demonstration of construct validity for our commitment-based HR practices measure, cautious interpretation is still in order, as researchers

have identified a number of measurement problems inherent in single-source HR measures (Gerhart, Wright, McMahan, & Snell, 2000). However, several of these concerns may not be problematic in our study. For example, Gerhart et al. (2000) noted that high correlations between single-source measures of HR practices and outcome measures might result from systematic error in the form of common method bias. Systematic error of this kind did not seem to be an issue in our study as we collected measures of HR practices, social conditions, and firm performance from separate sources. Further, Gerhart et al. raised concerns regarding attenuation as the result of random error in measurement associated with single-source measures of HR. Again, this potential problem did not seem to be a large concern in our study, given the size of the correlations between our HR measure and the mediator variables. Still, as Gerhart and his colleagues suggested, future research should collect measures of HR practices from multiple respondents to reduce the problems associated with this type of measurement error.

Despite these limitations, our study has a number of strengths. First, by limiting our focus to high-tech firms, we studied the effects of commitment-based HR practices on firm social climate conditions in a sample in which knowledge exchange and combination was extremely important for firm survival. If knowledge creation is an important capability for all firms, as Grant (1996) and Smith and colleagues (2005) suggested, then examining this process in high-tech firms should also yield insights for firms that are not in high-tech industries. Further, given the variance of our sample on industry and organizational size, our results should generalize to other knowledge-intensive firms facing similar environmental turbulence. An additional strength was our research design: we obtained data from independent sources for each firm, including secondary financial information, surveys of core knowledge workers, and surveys of HR executives. Because our independent, mediating, and dependent measures were collected from different sources, we avoided the percept-percept bias associated with single sources.

Our findings are further strengthened by the use of lagged data on firm performance. This practice enabled us to specify with some confidence that commitment-based HR practices, organizational social climate, and knowledge exchange and combination led to higher revenue from new products and services and improved sales growth in high-tech firms. Finally, this research provides one of the first full tests of a mediated relationship between commitment-based HR practices and firm

performance. Most researchers have not tested the proposed mediators of this relationship because data on organizational capabilities are difficult to obtain (Becker & Gerhart, 1996; Wright et al., 2001). By establishing these important links, our study offers guidance for future conceptual and empirical work on this important topic.

In conclusion, our study provides preliminary evidence on the role of firms' commitment-based HR practices in facilitating social climates of trust, cooperation, and shared language that lead to knowledge creation and resultant firm performance. In particular, we found that our measure of commitment-based HR practices was significantly related to the social climates of trust, cooperation, and shared codes and language that facilitate exchange and combination among knowledge workers. Moreover, these relational social climates of a firm mediated the relationship between commitment-based HR practices, knowledge exchange and combination, and two measures of firm performance. Our findings suggest that the leaders of high-technology firms should carefully choose the HR practices used to manage their knowledge workers, because these practices may shape the firms' social contexts, which, in turn, affect the firms' ability to create the new knowledge necessary for high performance and growth. As such, we are hopeful that the theory and findings presented in this paper can lead to more research on how firms can create knowledge-related advantages, especially in dynamic environments.

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APPENDIX A

Items Measuring a Commitment-Based Approach to HR

Selection Policies

1. Internal candidates are given consideration over external candidates for job openings.
2. We select employees based on an overall fit to the company.
3. Our selection system focuses on the potential of the candidate to learn and grow with the organization.
4. We ensure that all employees in these positions are made aware of internal promotion opportunities.

Incentive Policies

5. Employee bonuses or incentive plans are based primarily on the performance of the organization.
6. Salaries for employees in these positions are higher than those of our competitors.
7. Shares of stock are available to all core employees through stock purchase plans.

8. Goals for incentive plans are based on business-unit or company performance.

Training and Development Policies

9. We provide multiple career path opportunities for employees to move across multiple functional areas of the company.
10. We provide training focused on team-building and teamwork skills training.
11. We sponsor company social events for employees to get to know one another.
12. We offer an orientation program that trains employees on the history and processes of the organization.
13. We use job rotation to expand the skills of employees.
14. We have a mentoring system to help develop these employees.
15. Performance appraisals are used primarily to set goals for personal development.
16. Performance appraisals are used to plan skill development and training for future advancement within the company.

APPENDIX B

Items Measuring Knowledge Exchange and Combination

1. Employees see benefits from exchanging and combining ideas with one another.
2. Employees believe that by exchanging and combining ideas they can move new projects or initiatives forward more quickly than by working alone.
3. At the end of each day, our employees feel that they have learned from each other by exchanging and combining ideas.
4. Employees at this company are proficient at combining and exchanging ideas to solve problems or create opportunities.
5. 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)
6. Employees here are capable of sharing their expertise to bring new projects or initiatives to fruition.
7. The employees in this company are willing to exchange and combine ideas with their co-workers.
8. It is rare for employees to exchange and combine ideas to find solutions to problems. (reverse coded)



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