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The impact of team-member exchange, differentiation, team commitment, and knowledge sharing on R&D project team performance

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This paper integrates team-member exchange (TMX), affective commitment, and knowledge sharing to examine how work unit TMX influences employees' R&D project team commitment and intention to share knowledge, and how team knowledge-sharing intention and TMX differentiation influences team performance. The results support the relationships between work unit TMX and employees' intention to share knowledge and team commitment. In addition, the results show that work unit TMX increases intention to share knowledge through increasing group members' team commitment. At the group level, the results support the relationships between team knowledge-sharing intention and team performance. The results also show that TMX differentiation moderates the relationship between work unit TMX and team performance. That is, greater work unit TMX is more likely to achieve higher team performance in a team with low TMX differentiation as opposed to a team with high TMX differentiation. Implications for theory building, future research, and R&D management are discussed.

1. Introduction

An individual's perception of exchange relationships with coworkers of the work group was termed team-member exchange (TMX) by Seers (1989). Research suggests that TMX enhances individual performance and team effectiveness because individuals who experience high-TMX relationships are more willing to assist other members and to share information, ideas, and feedback within work teams (e.g., Seers, 1989; Liden et al., 2000). Furthermore, scholars and practitioners have increasingly posited that firm effectiveness is dependent on how well knowledge is shared among individuals, teams, and units (e.g. Kogut and Zander, 1996; Spender and Grant, 1996; Alavi and Leidner, 2001; Tsai, 2001), and that important information is identified and given a priority. Given the importance of the quality of TMX relationships for R&D project team functioning, it is critical to understand the underlying effect of the reciprocity between an

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individual and his/her team members and the team's influence on his/her willingness to share knowledge with others (Keller, 2001; Hoegl and Parboteeah, 2006).

Research has found that contextual factors such as human resource management practices (e.g., Bartol and Srivastava, 2002; Minbaeva, 2005) and top-level support (e.g., Liao and Chuang, 2007) can influence empowerment and employees' work outcomes. Especially critical contextual factors such as TMX, however, have largely been ignored (Liden et al., 2000). Rather than focusing on TMX at the individual level, a key extension of the present study is to consider the average level of TMX across a group as an aggregated group-level variable, which reflects the average reciprocity across the group, literally, the extent of teamwork in that group (Seers et al., 1995). The aggregated group-level TMX was defined as work unit TMX in this study.

Furthermore, previous work on knowledge sharing has focused on either organizational- or individual-level analysis. At the organizational level, this body of literature emphasizes the impact of managerial practices and organizational culture on knowledge sharing (e.g., Floyd and Lane, 2000; Bartol and Srivastava, 2002), team and organizational learning in new product development (Lynn, 1998), and cooperation patterns in cross-functional teams (Olson et al., 2001). In work addressing individual factors, researchers have linked employees' personality and disposition to their knowledge sharing (e.g., Szulanski, 1996; Cabrera et al., 2006; Mooradian et al., 2006). However, little work has been focused on the antecedents and consequences of knowledge sharing from a multilevel perspective.

The purpose of this study was to provide a more comprehensive picture of how work unit TMX influences team commitment, employees' intention to share knowledge, and team performance in R&D project teams. The expected contribution of this study is to explore the cross-level mediating role of team commitment on the relationship between work unit TMX and intention to share knowledge via hierarchical linear modeling (HLM; Raudenbush and Bryk, 2002). This multilevel focus has often been neglected in the prior literature on R&D project teams and can contribute to this literature. To wit, the reality of R&D organizations is that multiple project teams are usually at work and often share knowledge within and across teams (Keller, 2001). Hence, we consider TMX as a work-unit phenomenon in predicting outcomes targeted at peers. Specifically, we attempt to advance the research on TMX in three ways. First, we conceptualize TMX as a team-level construct and examine its effects on individual constructs such as individual team commitment and intention to share knowledge. Although the implications for TMX have been implicit in both the social exchange literature and employees' work attitudes and behaviors' literature, they have not been made theoretically explicit in a team-level study. Considering TMX as a group/work unit construct rather than as individual perceptions for their relationships with other team members reveals an important yet neglected fact; that is, team projects are conducted by teams rather than individual team members. Work can best be done when a whole team possesses the willingness to cooperate with each other. The reasoning here is that work unit TMX determines the extent to which a team possesses the ability to work as a team.

Second, we posit here that a team with high work unit TMX can perform better than a team with average work unit TMX, but that has one or two team members with an extremely high individual relationship with other members. Further, prior research on TMX has not usually recognized TMX differentiation, which we define as the consistency of how each team member perceived their team-member exchange within a group. We believe that a group with uniformly high perceptions of TMX for all team members performs differently than a group with similar average of work unit TMX, but with extremely high TMX perceptions for two team member and extremely low TMX perceptions for another two team members. We argue that TMX differentiation has special relevance to behaviors in R&D project teams; hence, we extend the TMX literature by conceptualizing the construct of TMX differentiation and investigate the moderating role of TMX differentiation in the relationship between work unit TMX and R&D project team performance.

Finally, our paper identifies the underlying effect of work unit social exchange on employees' attitude of diffusing one's own knowledge with other group members. Research has acknowledged contextual factors such as organizational culture and organizational support as factors influencing employees' psychological variables such as commitment. However, critical contextual factors, including social interactions, have largely been ignored (Liden et al., 2000). Our study responds to the call of Liden et al. and considers

social exchange as a contextual factor. Furthermore, prior studies suggest that psychological variables such as self-efficacy, organizational commitment, or perceived instrumentality may have a significant impact on people's inclination to participate in voluntary knowledge sharing (e.g. Cabrera et al., 2006). Our paper expands on this line of research by highlighting the importance of how work unit TMX can facilitate employees' intention to share knowledge through their team commitment. Because contextual factors contribute to employees' commitment, it would be incomplete to study how contextual factors influence knowledge sharing without investigating the cross-level mediating role of commitment. As there are few studies in the area of knowledge sharing that consider social exchange as a group/work unit construct influencing employees' team commitment and sharing intention, our study fills a gap in the knowledge-sharing literature by acknowledging social exchange as a contextual factor and as a salient, unexplored research area.

2. Theory and hypotheses

2.1. TMX and intention to share knowledge

TMX is a way to assess the reciprocity between a member and his or her team. Thus, the quality of the team-member exchange relationship indicates the effectiveness of the member's working relationship to the peer group (Seers, 1989). Teams are extensively used in organizations and these proximal coworker relationships can have powerful implications for employee attitudes and behaviors at work (Ilgen, 1999).

Our rationale for positing a relationship between TMX and employees' intention to share knowledge is derived in part from the theory of social exchange (Blau, 1964). Social exchange assumes that people participate in exchange behavior because they think their reward will justify their cost. Cropanzano et al. (2001) suggested that social exchange relationships evolve when employers take care of employees, which thereby produces effective work behavior and positive employee attitudes. The same exchange relationships could be developed among group members when one perceives the mutual and reciprocal caring and trust from one another (Dayan et al., 2009). According to Molm et al. (2000), reciprocity engenders better work relationships and allows for individuals to be more trusting of and committed to one another. For individuals whose sense of belonging is strong, engaging in organizational citizenship behavior may become an important way to reciprocate the favors received from one's coworkers. Findings suggest that individuals with a strong exchange orientation are more likely to return a good deed than those low in exchange orientation. For instance, research has suggested that coworker support (Settoon and Mossholder, 2002) and friendship (Bowler and Brass, 2005) are positively related to both the giving and the receiving of helping behavior among employees. Liden et al. (2000) suggested that individuals experiencing low-TMX relationships with their coworkers often limited their exchanges with others that are required for task completion, whereas those experiencing high-TMX relationships tend to engage in exchanges of resources and supports, which may result in acts of higher levels of knowledge-sharing behavior. Figure 1 depicts the theoretical framework and hypotheses for the present study.

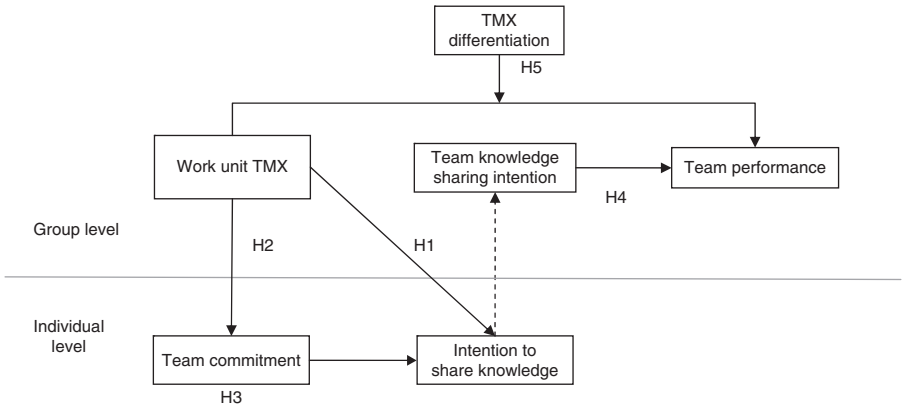

Figure 1. A theoretical multi-level research framework for R&D project teams.
Note: The dashed line represents additive processes through which individual-level phenomena are compiled to form group-level phenomena

Rather than focusing on TMX at the individual level, the present study treats TMX as a team-level climate, which focuses on the role of TMX directed toward the R&D project team as a whole. We proposed that 'work unit TMX' refers to the overall pattern of team member exchange relationships displayed to the entire work unit; it can be viewed as a climate indication of a positive social exchange characterized by the flexibility, discretion, and open-ended relationships shared among unit members. We predict that employees who work in a strong TMX climate may be more willing to reciprocate toward coworkers to show that they value these social exchange relationships, whereas those perceiving a weak TMX climate may hoard information to minimize the risk in the context of exchange that the coworker will not reciprocate efforts made on the other's behalf. Thus, we expect that the quality of work unit TMX has relevance to employees' intention to share knowledge.

Hypothesis 1: *Work unit TMX is positively related to employees' intention to share knowledge*.

2.2. TMX and team commitment

Affective commitment is usually defined as 'the relative strength of an individual's identification with and involvement in a particular organization' (Mowday et al., 1982, p. 27). Eisenberger et al. (1986) defined exchange ideology as the strength of an employee's belief that work effort should depend on treatment by the organization. They found that the relation between perceived organizational support and absenteeism is greater for employees with a strong exchange ideology than those with a weak exchange ideology. Yet, the effects of exchange ideology are not limited to perceived organizational support. In accordance with social exchange theory, we argue that TMX may generate stronger exchange ideology, which in turn may contribute to a sense of team commitment through a process of reciprocation (Liden et al., 2000). Social exchange relationships evolve over time into loyal and mutual commitments (Cropanzano and Mitchell, 2005). To the degree that the perceived exchange relationships met the needs for praise and approval, the employee would embody group membership and role status into self-identity and thereby develop an affective commitment to the team. Given the positive psychological attachment developed in groups shaped by greater exchange relationships, we argue that members are more likely to demonstrate higher attachment and loyalty in such groups. Thus, we hypothesized:

Hypothesis 2: *Work unit TMX is positively related to individual-level team commitment*.

2.3. Cross-level mediation effect of affective commitment

Employees' knowledge-sharing intention refers to the willingness to diffuse knowledge with other group members. Research has revealed that employee attitudes impact their knowledge-sharing attitude and behavior (Osterloh and Frey, 2000; Hall, 2001; Minbaeva et al., 2003; Kwok and Gao, 2005). Commitment refers to an individual's psychosocial attachment, loyalty, and identification with the organization (Meyer et al. (1993), and Kalman et al. (2002) and Cabrera et al. (2006) suggest that psychological variables such as organizational commitment have a significant impact on one's inclination to participate in knowledge and information sharing. Organ and Ryan (1995) conducted meta-analysis research and found that affective commitment was significantly related to altruism that would promote employees' knowledge-sharing intentions. In a related study, Kane et al. (2005) found that knowledge was more likely to be shared when team members had a common social identity. Because of the collective nature of team work, emotional attachment to and identification with the team can contribute to the achievement of knowledge-sharing behavior.

Given that an R&D project team with high TMX relationships is likely to create conditions under which employees can develop higher identity and commitment toward the team (Seers et al., 1995), we expect that the overall pattern of team member exchange relationships displayed to the entire work unit helps to promote employees' willingness to share knowledge through increasing commitment with their work unit. Hence:

Hypothesis 3: *Team commitment mediates the relationship between work unit TMX and employees' intention to share knowledge*.

2.4. Team knowledge sharing and team performance

Working together is more productive than working as individuals. This philosophy is based on a fundamental premise of collaboration in the

work. R&D project teams are groups of individuals with experiences and knowledge both different from and complementary to those responsible for a work process or goal (Zárraga and Bonache, 2003). When the complementariness of team members' knowledge is shared and transferred from one to another within a team, a synergy then occurs. Knowledge sharing is likely to develop collective knowledge (Grant, 1996; Nahapiet and Ghoshal, 1998; Cabrera et al., 2006) through which the integration of the individual's knowledge will surpass the sum of what each individual can do. No single individual can manage to carry out all the activities necessary to produce improvements and innovations in the collective work process. Only by combining individuals with different and complementary skills and perspectives, and by achieving co-operation among them, can this process be carried out and improvements and innovations be made (Swan et al., 1999; Keller, 2001; Zárraga and Bonache, 2003).

Srivastava et al. (2006) suggested that knowledge sharing in teams improves team performance because of its beneficial effect on team coordination. Knowledge sharing may lead to improved coordination because of the development of transactive memory, defined as the knowledge of 'who knows what' in a team (Wegner, 1987; Srivastava et al., 2006). With the formation of transactive memory, the team will be more likely to obtain the resources needed for managing project-related challenges, such as help with timely prototype development and commitment of appropriate personnel, and thus result in achieving project goals that are timely and cost-efficient. Thus, the above arguments suggest that knowledge sharing is likely to lead to higher team performance.

Hypothesis 4: *Team knowledge-sharing intention is positively related to team performance.*

2.5. Moderation effect of TMX differentiation

The literature on TMX has suggested that a high-quality TMX relationship enhances team functioning and work performance. We expect that if perceptions of team-member exchange within a group were uniformly high, the group would approximate the ideals sought in team building, where members perceive the group to be both well coordinated and cohesive (Seers, 1989). Thus, the effect of work unit TMX on R&D project team performance would be posited to be stronger when team members perceive similar working relationships with their peers. In other words, when work unit TMX levels are high on average, and when the TMX relationships are similar for all members (low TMX differentiation), we expect that the team's sense of coordination and cohesiveness that elevates knowledge sharing will lead to a higher team performance. When work unit TMX levels vary considerably among team members, however, we expect that work unit TMX may have less influence on team performance because knowledge sharing among team members would be hampered. Thus:

Hypothesis 5: *TMX differentiation moderates the relationship between work unit TMX and team performance at the team level, such that the relationship between work unit TMX and team performance will be stronger in groups with lower levels of TMX differentiation than in groups with higher levels of TMX differentiation.*

3. Method

3.1. Participants and procedures

A solicitation letter was first sent out to 84 technology-driven companies in Taiwan to request their participation in this study. Fifty-six companies accepted the request to participate. Survey packages were sent out to each R&D project team in the companies where the team was working on a specific project when the data collection was conducted. Each package contained copies of team member questionnaires and one copy of the leader questionnaire. To ensure the anonymity of employee responses, we instructed an employee representative in each team to collect sealed surveys from employees. Employees were also provided with the option of sending their responses directly to the researchers via mail or email. Because the survey was conducted in Taiwan, a translation–back-translation procedure (Brislin, 1980) was followed to translate the English-based measures into Chinese. The original English version and the English back-translation reached high agreement.

The estimates for Hierarchical Linear Modeling (HLM) in this study required at least five respondents per group. After excluding four teams because of incomplete data and with an insufficient number of respondents, the final sample consisted

of 301 surveys from individuals representing membership in 52 R&D project teams, all from different companies. The sample consists of five companies in the semiconductor industry, six companies in information technology, nine companies in electronics, nine companies in photonics, five companies in petrochemicals, three companies in biochemistry, and 15 companies in manufacturing.

The number of respondents per team ranged from five to seven, with an average of 5.78 respondents per team. The average number of members per team was 6.29, which resulted in a response rate of 92.8%. The response rates ranged from 71.4% to 100% across the teams. Nonresponse bias may obfuscate the interpretation of relationships between independent and dependent variables. Given that our responses were collected by the team leader or the employee representative at the same time in each team, we were not able to conduct a wave analysis comparing early to late respondents on the measures. However, we collected additional demographic information on the entire cohort of R&D teams we investigated to conduct an archival analysis suggested by Rogelberg and Stanton (2007). Proportions of respondents were quite similar to the entire cohort of R&D teams we investigated in terms of gender (male: 70.1% vs 70.9%), tenure (5.12 vs 5.09), and age (33.1 vs 33.3). These results reduce the concern that there are significant differences between respondents and nonrespondents.

Approximately 70% of the team members in the final sample were male, while about 77% of team leaders were male. Of the team members, the average age was 33 years and company tenure was 5 years. Of the team leaders, the average age was 42 years and tenure was 9 years. All the team members had a college degree and 40% had a master's or a doctoral degree. All of the team leaders had a college degree and 58% had a master's or a doctoral degree.

3.2. Measures

3.2.1. Team-member exchange

TMX was measured using 10 items from Seers et al. (1995) ($\alpha = 0.88$). The scale measures the perception of the reciprocal exchange relationship between an individual member and his or her team members. Responses were measured on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). A sample item is 'In busy situations, how often do you volunteer your efforts to help others in your team?'

3.2.2. Work unit TMX

Work unit TMX was adopted as an indication of a TMX relationship climate. The score of work unit TMX was averaged from the individual TMX score within each team following the aggregation method by James et al. (1984) and Kozlowski and Hults (1987).

3.2.3. TMX differentiation

The r_{WG} value was used to calculate the score of within-team TMX differentiation. The r_{WG} index is typically used as a measure of agreement. Based on prior research, the r_{WG} index was an appropriate estimate of TMX relationships in a team despite the target differences (e.g. Boies and Howell, 2006). James et al. (1984) suggested that r_{WG} values should range between 0 and 1; however, one of the problems with the r_{WG} index is that it sometimes generates out-of-bound values. Thus, we removed one team from the sample, given that its LMX r_{WG} value was out-of-range. The decision to remove the team is consistent with Boies and Howell's (2006) study on within-team differentiation on leader-member exchange.

3.2.4. Team commitment

The 6-item affective commitment scale from Meyer et al. (1993) was used to measure team commitment ($\alpha = 0.86$). Responses to these items were made on a 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree). An example item for measuring organizational commitment is 'I feel a strong sense of belonging to the team.'

3.2.5. Intention to share knowledge

Five items adapted from Bock et al. (2005) with responses ranging from 1 (extremely unlikely) to 5 (extremely likely) were used to assess an individual's intention to share knowledge ($\alpha = 0.88$). An example item is 'I try to share my expertise from my education or training with other group members in a more effective way.'

Common method bias may artificially inflate observed relationships between variables. In this study, team commitment and individual intention to share knowledge were the two self-reported data that may lead to common method bias. To address the concern of common method bias in this study, we examined the data using Harman's one-factor test (Podsakoff and Organ, 1986): items at the individual level including team commitment and individual intention to share knowledge were considered in a factor analysis to determine whether the majority of the variance

could be accounted for by one general factor. The results of the principal component factor analysis revealed two factors, with Eigenvalues greater than one explaining 63.6% of the total variance. The first factor accounted for 47.3% (<50%) of the variance, which did not account for a majority of the variance (Podsakoff and Organ, 1986). Therefore, we concluded that our data did not suffer substantially from common method bias.

3.2.6. Team knowledge sharing intention

To assess the overall team knowledge sharing across a group, we averaged team members' evaluation of their individual intention to share knowledge to form the team knowledge-sharing intention score, following the aggregation method by James et al. (1984) and Kozlowski and Hults (1987).

3.2.7. Team performance

Four items adopted from Marrone et al. (2007) were used to measure team performance ($\alpha = 0.80$). Team leaders at each team were asked to respond on a 7-point scale. Sample items include 'The team members meet specified project deadlines in a timely manner' and 'The team members are successfully managing project-related challenges or obstacles as they occurred'. The use of team leaders as a separate source for the dependent variable of team performance from that of the independent variables measured by team members helps to minimize the concern of common method bias.

3.2.8. Control variables

We controlled for group age and size in the testing of group-level hypotheses. Group age was operationalized as the number of years that the group had been in operation. Group size was operationalized as the number of employees in the work group. Both of these were obtained from team leaders' self-reports. We also controlled for employees' gender, age, education, and team tenure in the testing of individual-level hypotheses.

3.3. Analysis techniques

Hierarchical linear modeling (HLM) was used to test the hypotheses because it provides an appropriate estimate of standard errors that is better than that provided by other analytic methods when data are nested in groups. HLM can simultaneously estimate the impact of factors at different levels on individual-level outcomes while maintaining appropriate levels of analysis for the predictors (Raudenbush et al., 2001; Raudenbush and Bryk, 2002). In conducting the analyses, we controlled for a number of variables, including employees' gender, age, education, and team tenure. No significant effects for these control variables were found in the analyses. All variables examined in the HLM analysis were grand-mean centered as this reduces possible multicollinearity and helps address the interpretation of intercepts and the variance of random intercepts across groups (Hofmann and Gavin, 1998). In addition, Kenny et al.'s (1998) approach and Sobel's tests (1982) were used to examine the mediation effects.

4. Results

The means, standard deviations, and correlations for the study variables are shown in Table 1. The discriminant validity of each construct was assessed by testing whether or not the square root of the average variance extracted for each construct was greater than the correlations between the construct and other constructs (Fornell and Larcker, 1981). Table 1 shows that the constructs

Table 1. Means, standard deviations, and correlations

	M	SD	1	2	3	4	5	6
Individual-level variables								
Team commitment	4.63	1.12	0.71					
Intention to share knowledge	3.91	0.55	0.46**	0.78				
Group level variables								
Group age	13.69	12.54						
Group size	5.75	0.93	−0.13					
Work unit TMX	3.70	0.31	0.03	0.21				
Team knowledge sharing intention	3.91	0.34	0.10	0.11	0.81**			
TMX differentiation	0.96	0.03	−0.19	0.11	0.24**	0.09		
Team performance	5.12	0.94	−0.12	0.42**	0.51**	0.47**	−0.17	0.79

Note: The square roots of the average variance extracted for each construct underlined and shown in the diagonal. $n = 52$ project teams.
**$P < .01$ (two-tailed significance).

meet this criterion. We calculated the variance inflation factor after mean centering and before the calculation of the interaction terms. The highest VIF, 2.96, found for team knowledge-sharing intention in the full model was well within an acceptable range (Hair et al., 2006).

4.1. Aggregation statistics

The viability of creating aggregated measures of work unit TMX and team knowledge-sharing intention was checked following the method by James et al. (1984) and Kozlowski and Hults (1987). The within-group agreement (r_{wg}), intraclass correlation (ICC1), and reliability of the mean (ICC2) were computed. The mean values of r_{wg} computed for TMX and intention to share knowledge was 0.92 and 0.91, respectively. The computed ICC(1) and ICC(2) values for TMX were 0.54 and 0.87, respectively. The computed ICC(1) and ICC(2) values for intention to share knowledge were 0.35 and 0.75, respectively. The mean r_{wg} values and ICC values were well above acceptable levels (e.g. Bliese, 2000). Thus, the aggregated measures of both work unit TMX and team knowledge-sharing intention were justified.

4.2. HLM results

In order to test these hypotheses, we estimated a null model in which no predictors were specified for either the level 1 or the level 2 function to test the significance level of the level 2 residual variance of the intercept. The result ($\hat{\tau}_{00} = .07$, $P < 0.01$; Model 1) indicated a significant between-group variance in intention to share knowledge.

The results of tests of the hypotheses appear in Table 2. Hypothesis 1 postulated that work unit TMX is positively related to intention to share knowledge. As can be seen in Model 3, work unit TMX had a significantly positive relationship with intention to share knowledge ($\hat{\gamma} = .88$, $P < 0.01$). As predicted in Hypothesis 2, work unit TMX had a significantly positive relationship with team commitment ($\hat{\gamma} = 1.45$, $P < 0.01$; Model 5). Thus, both Hypotheses 1 and 2 were supported.

4.3. Testing cross-level mediation

Hypothesis 3 proposed that team commitment mediates the relationship between work unit TMX and employees' intention to share knowledge. The Kenny et al. (1998) procedure was used to test mediation. In the first step, work unit TMX needed to be related to intention to share knowledge, which was supported in our testing of Hypothesis 1. Second, work unit TMX needed to be related to team commitment, which was supported in our testing of Hypothesis 2. Third, team commitment had to relate to the intention to share knowledge, which was also supported in Model 2 ($\hat{\gamma} = 0.24$, $P < 0.01$). To demonstrate full mediation, the relationship between the predictor and the outcome variable should be reduced to non-significance when both the predictor and the mediator are included in the regression equation. If the relationship between the predictor and the outcome variable remain significant when the mediator is included, but the relationship is reduced, then partial mediation is demonstrated. In testing mediation, we included both work unit TMX and the mediator (team commitment) in the regression. The results in Model 4 showed that the relationship between work unit TMX and intention to share knowledge remained significant ($\hat{\gamma} = 0.56$, $P < 0.01$), but to a reduced degree compared with the effect in Model 3 ($\hat{\gamma} = 0.86$, $P < 0.01$). This means that the relation between work unit TMX and employees' intention to share knowledge was partly explained by employees' team commitment. Hence, Hypothesis 3 was supported for partial but not full mediation.

Finally, Sobel's tests, which MacKinnon et al. (2002) found to provide a better balance between Type I and Type II errors, were also conducted to further support the mediation model as predicted (Hypothesis 3). The computed statistic measures the indirect effect of the independent variable (work unit TMX) on the dependent variable (intention to share knowledge) by way of the mediator (team commitment). The results of Sobel tests further supported Hypothesis 3 ($z = 4.10$, $P < 0.001$) for partial mediation.

4.4. Testing group-level hypotheses

Hypothesis 4 postulated that team knowledge-sharing intention is positively related to R&D project team performance. As can be seen in Model 7, team knowledge-sharing intention had a significantly positive relationship with team performance ($\beta = 0.60$, $P < 0.01$), thus supporting Hypothesis 4.

Hypothesis 5 proposed a moderating effect of TMX differentiation on the relationship between work unit TMX and team performance. We tested Hypothesis 5 using hierarchical moderated

Table 2. Results of data analyses

Variable	Intention to share knowledge				Team commitment	Team performance			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Individual level									
Intercept	3.92** (0.07**)	2.61**	3.76**	2.90**	4.66**				
Gender		−0.07	−0.08	−0.06	−0.11				
Age		0.00	0.00	0.00	0.03				
Education		0.06	0.02	0.04	−0.02				
Team tenure		−0.01	−0.02	−0.01	0.00				
Team commitment		0.24**		0.20**					
Team level									
Group age			0.00	0.00	0.00	−0.14	−0.19	−0.16	−0.15
Group size			−0.01	−0.00	−0.04	0.03	−0.05	−0.01	0.06
Work unit TMX			0.86**	0.56**	1.33**		0.19	0.26	0.29
TKSI							0.60**	0.63**	0.60**
TMX differentiation								−0.13	−0.11
Work unit TMX × TMX differentiation									−0.27*
R^2						0.02	0.22	0.24	0.30
Adj. R^2						0.02	0.15	0.15	0.21
Within-group residual variance	0.23	0.18	0.23	0.17	0.89				
$R^2_{within-group}$ [a]		0.21							
Deviance	473.6	412.9	450.2	400.2	862.4				

Note. Models 1, 2, 3, 4, and 5 represent the results of HLM analyses. Entries are estimations of fixed effects (γs) with robust standard errors. Estimations of the random variance components (τs) are in parentheses. Models 6, 7, 8 and 9 represent the results of hierarchical regression analyses. TMX, team-member exchange; TKSI, team knowledge-sharing intention.

[a]Explained within-group variances in intention to share knowledge by level 1 predictors.

*$P<0.05$;

**$P<0.01$.

regression analysis. Following the guidelines by Aiken and West (1991), the interaction term was entered into the equation after both TMX differentiation and work unit TMX were entered in the first step. All variables were centered (by subtracting the means) before the analyses to reduce nonessential collinearity from testing moderated relationships (Aiken and West, 1991; Cohen et al., 2003). Control variables such as group age and size were included in both steps. As can be seen in Model 9, the result supported Hypothesis 5 ($\beta = -0.27$, $P < 0.05$). Figure 2 shows the graph with the interaction effect to better explain the form of interactions reported in the above hierarchical regression analysis. The graph was plotted following the procedures suggested by Aiken and West (1991). One standard deviation above and below the mean were computed to capture both high and low TMX differentiation.

It is interesting to note that work unit TMX does not directly affect team performance (model 6 to model 9). To further examine whether this result is from the mediation effect of team knowledge-sharing intention, we tested whether team knowledge-sharing intention mediates the relationship between work unit TMX and team performance. The analysis, however, did not show a mediation effect for team knowledge-sharing intention on the relationship between work unit TMX and team performance.

5. Discussion and implications

The present study has yielded some important findings about how the relationships among team-member exchange, affective commitment, knowledge sharing, and team commitment relate to the performance of R&D project teams. These findings provide some important new insights that can improve theory building about how processes within the project team lead to R&D outcomes, and our findings also have some useful normative implications for project leaders to improve team effectiveness and innovation.

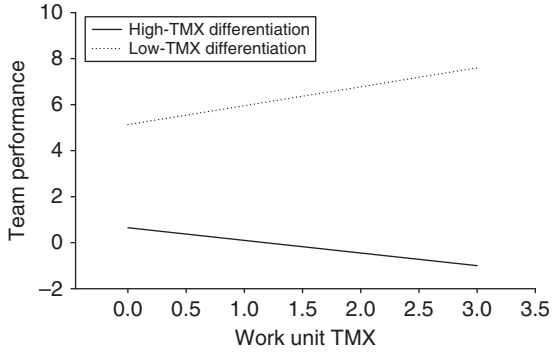

Figure 2. The relationship between work unit TMX and team performance for high and low TMX differentiation.

This study contributed to theory about R&D project teams in three ways. First, we extend the TMX literature by conceptualizing TMX as a group-level construct and investigating its impact on team performance and on individual constructs. Treating TMX as a group-level construct responds to the call of Liden et al. (2000). We found that the quality of team-member exchange is related to increased intention among team members to share knowledge and to increased commitment to the team. Knowledge sharing at the team level is then associated with higher project performance. These results enhance our understanding of how work unit TMX influences team performance. In addition, our HLM results add to the emerging body of TMX research by revealing that work unit TMX serves as a group-level construct.

A practical implication of this set of findings suggests the importance of quality interactions among team members to develop the trust and commitment to the team and project that can then enhance the crucial sharing of scientific and technological knowledge at the team level. Team knowledge sharing can then be transformed into prototypes and new products that are hallmarks of high-performing R&D project teams.

Second, our findings, in effect, suggest a virtuous cycle where the day-to-day interactions and exchanges of a positive, productive nature can lead to a feeling of commitment, identification, and belongingness to the project team, and that in turn enhances the sharing and dissemination of technical knowledge among team members. By sharing and disseminating knowledge among team members, the transformation of scientific and technical information into higher project performance and innovative outputs is achieved, with the logical expectation that future TMX is of higher quality. Because the present data are cross-sectional, however, we cannot identify the direction or the reciprocal nature of the relationships. While we suspect that there are cyclical and reciprocal relationships among TMX, team commitment, intention to share knowledge, and project performance and innovativeness, a longitudinal or a laboratory design would be needed to test for these relationships.

Third, our study extended the scope of TMX research by conceptualizing the concept of TMX differentiation in teams that is a new contribution to the literature that investigates the impact of

TMX differentiation on team performance. In this regard, our findings show that work unit team member exchange relations are more likely to result in higher project performance in a team with low TMX differentiation than in a team with high TMX differentiation. These results suggest that greater work unit TMX may not have a positive influence on team performance if the variation of exchange working relationships among team members is high. In other words, the uniformity of working relationships that team members have with their peers may act as a basis to solidify the influence of work unit TMX on team performance.

Our finding that TMX differentiation moderates the TMX-team performance relationship suggests that TMX differentiation should be included in theoretical frameworks about R&D project team performance. When teams have high TMX differentiation, different social exchange relationships among team members jeopardize the role of TMX. This finding suggests that high TMX differentiation can impair the positive effect of TMX. We note that the interaction effect conformed to this same pattern.

A practical implication that emerges from this finding is that in team-based R&D organizations, leaders should be attentive to differentiated relationships building among team members. High TMX differentiation may lead to a lower sense of unity within the team, which in turn appears to be detrimental to the contribution of work unit TMX to project team performance. Our findings generally support the model in Figure 1, and we believe that the importance and effects of the concept of TMX differentiation reflect the leader's task assignments, coordination of team work, and resulting team performance.

Normative implications for the management of R&D project teams can also be drawn from the present findings. Our findings suggest that leaders should encourage the development of open and trustful relationships among team members, with a resulting feeling of commitment to the team and its performance outcomes. These relationships can enable and foster the sharing of scientific and technological knowledge in the team, with the result of high project performance and innovative outputs. Project team leaders should be aware of the importance of the interpersonal exchange relationships among team members for successful outcomes, perhaps as important as the scientific and technical information inputs of the work.

The research design of the present study can provide some confidence in the results and their ability to be generalized to other R&D project teams in other technology-driven organizations. Namely, the use of multiple organizations, performance measures from a source separate from that of the independent variables and the use of hierarchical linear modeling that accounts for the nesting of individuals within their project teams lend a substantial degree of rigor to the research.

The limitations of this study should be noted. First, while it was advantageous to have the separate-source data for team performance obtained from team leaders, these data were subjective ratings and not objective outcomes such as counts of patents or prototypes. Further, we cannot show that our ratings of team performance are predictors of such outcomes. Future research may advance this study with a longitudinal approach by measuring actual outcomes with a time lag. Second, we measured the intention to share knowledge, not actual knowledge sharing itself. More intensive future studies could examine the linkages between the intent and the act, and whether the predictors evaluated here have the same relevance in both contexts. Researchers may also want to use a more finely grained measure of information sharing that can test whether important information is identified and given a priority for sharing.

6. Conclusion

Our findings taken as a package present an improved and more coherent understanding of the relationships among the processes and outcomes at both the individual and the team level for R&D projects. Namely, we found that TMX can increase commitment to the team and the intention to share and disseminate scientific knowledge among team members, with the results being improved R&D project team performance and innovativeness. The model in Figure 1 depicts these important multilevel interrelationships among team processes and performance outcomes in a way that can enhance our theoretical understanding of project teams, and suggest some actions that project leaders can take to improve team effectiveness.

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Appendix

Constructs and measures

Team-member exchange (Seers et al., 1995)

1. How often do you make suggestions about better work methods to other team members?
2. Do other members of your team usually let you know when they have done something that makes your job easier (or harder)?
3. How often do you let other team members know when they have done something that makes your job easier (or harder)?
4. How well do other members of your team recognize your potential?
5. How well do other members of your team understand your problems and needs?
6. How flexible are you about switching job responsibilities to make things easier for other team members?
7. In busy situations, how often do other team members ask you to help out?
8. In busy situations, how often do you volunteer your efforts to help others on your team?
9. How willing are you to help finish work that had been assigned to others?
10. How willing are other members of your team to help finish work that was assigned to you?

Team commitment (Meyer et al., 1993)

1. I would be very happy to spend the rest of my career with this organization.
2. I really feel as if this organization's problems are my own.
3. I feel a strong sense of 'belonging' to my organization.
4. I do not feel 'emotionally attached' to this organization. (R)
5. I do not feel like 'part of the family' at my organization. (R)
6. This organization has a great deal of personal meaning for me.

Intention to share knowledge (Bock et al., 2005)

1. I will share my work reports and official documents with members of my organization more frequently in the future.
2. I will always provide my manuals, methodologies and models for members of my organization.
3. I intend to share my experience or know-how from work with other organizational members more frequently in the future.
4. I will always provide my know-where or know-whom at the request of other organizational members.
5. I will try to share my expertise from my education or training with other organizational members in a more effective way.

Team performance (Marrone et al., 2007)

1. The team members meet specified project deadlines in a timely manner.
2. The team members provide recommendations that are feasible (i.e., can realistically be implemented)
3. The team members are successfully managing project-related challenges or obstacles as they occurred.
4. The team members managed their time with you and other members of your company effectively.

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