



Knowledge networks in new product development projects: A transactive memory perspective

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Received 27 August 2004; received in revised form 26 November 2004; accepted 9 January 2005

Available online 23 February 2005

Abstract

Even though an individual's knowledge network is known to contribute to the effectiveness and efficiency of his or her work in groups, the way that network building occurs has not been carefully investigated. In our study, activities of new product development teams were analyzed to determine the antecedents and consequences on the transactive memory systems, the moderating affect of task complexity was also considered. We examined 69 new product development projects and found that team stability, team member familiarity, and interpersonal trust had a positive impact on the transactive memory system and also had a positive influence on team learning, speed-to-market, and new product success. Further, we found that the impact of the transactive memory system on team learning, speed-to-market, and new product success was higher when there was a higher task complexity. Theoretical and managerial implications of the study findings are discussed.

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Keywords: Transactive memory system; Knowledge network; Team learning; New product development

1. Introduction

Knowledge management in the group dynamics and behavior literature has been receiving great deal of interest recently and scholars have been investigating the ways of managing group knowledge, such as generating, capturing, storing, sharing, and implementing it [6,63,68,77,83]. Within such practice, *knowledge*

networking (the webs of personal relationships) is imperative to perform group activities effectively [30,84]. Alavi and Tiwana [2] pointed out that knowledge networking in groups or teams is effective if its members know who has the required knowledge and expertise, where the knowledge and expertise are located, and where and when they are needed: the knowledge needed to complete group tasks is distributed among group members and no individual needs to know all the detailed knowledge or to be fully cognizant of every aspect of the project [13]. Thus interpersonal awareness of others' knowledge is essential.

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The idea of knowledge networking in general and interpersonal awareness of other's knowledge in particular have been investigated as the transactive memory system (TMS) in small group management research [33,51]. A TMS requires that individuals, in continuing relationships, utilize each other as memory sources or aids to supplement their own limited and unreliable memories and knowledge [79]. A TMS provides a knowledge network among individuals allowing the interchange of data, information, and knowledge. However, empirical investigations were mostly conducted in laboratory conditions, on relationships among intimate couples and small groups, and ignoring multi-functional work groups, such as new product development (NPD) teams.

Such project teams are specific forms of organizational work-groups. NPD projects generally involve [14,20,23]:

- people with different views, perspectives, functional backgrounds, and knowledge, and concurrently, their interaction with other units in the organization;
- team processes (e.g., conflict management, motivation, teamwork); and
- project related task work.

This complex nature of NPD projects requires effective team knowledge of who has and needs particular information. For instance, Lewis [42] argued that they benefit when team members utilize their unique expertise and integrate the differentiated expertise of other members. She further stated that such a TMS was “an especially appropriate concept for understanding how knowledge-worker teams can optimize the value of members' knowledge.” Thus, investigating TMS theory in NPD project teams could be valuable by helping recognize networking task-specific expertise and knowledge for project related tasks. Accordingly, the goal of our study was to investigate the factors effecting TMS and the consequences of it in an NPD project team context.

2. Background

2.1. TMS and new product development

Transactive memory, in the mind of an individual, is influenced by other people. Scholars (e.g., [72])

have showed that transactive memory forms beliefs about the knowledge possessed by others and affected accessibility to that knowledge. For instance, Wegner [78] noted that it began when individuals learnt something about someone else's domains of expertise.

A TMS occurs when two or more people cooperatively store, retrieve, and communicate information and knowledge [29]. It is formed by individuals playing the role of external memory for others who, in turn, encode memories about the memories of others. Thus, a TMS consists of the memory stores of particular individuals and any social interactions in which they participate [81]. As Wegner [80] said, “One person has access to information in another's memory by virtue of knowing that the other person is a location for an item with a certain label. This allows both people to depend on communication with each other for the enhancement of their personal memory storage.” Thus a TMS tacitly coordinates who will learn what from whom, and then aids the dissemination of that knowledge [32]: people rely on others to process and encode knowledge related to their area of expertise within a TMS [34].

Early studies on TMS were based on dyadic relations and were empirically tested in laboratory settings [7]. In order to enhance the individual level theory of TMS, group level studies proposed that TMSs had three major components:

- *Specialization*: The differentiated structure of member knowledge.
- *Credibility*: Members' beliefs about the accuracy and reliability of other members' knowledge.
- *Coordination*: Effective and orchestrated knowledge processing.

Moreland [55], using a radio assembling experiment, found: that *specialization* showed that one person remembered where components should be inserted in a circuit board while another knew how the circuit boards should be wired together, *coordination* explained how group members worked together efficiently on the radio, and *credibility* showed the degree of trust among group members of other members' radio knowledge. Studies on TMS in real-world workgroups were underestimated, with the exception of a few studies such as Faraj and Sproull's [22] investigation of the impact of expertise coordination.

Researchers have described new product development as a knowledge-intensive activity and that a cross-functional team was a primary vehicle for such activities [58]. Huang and Newell [36] argued that cross-functional project teams enabled a firm to merge a range of expertise from various units to accomplish complex tasks and enhance the quality of decision making by considering multiple perspectives. However, teams were seen to be challenged by the need for synergy among team members, deficient knowledge exchange, and lack of an effective knowledge network. A project team needs to utilize diverse knowledge and incorporate new information into its collective understanding to solve technical, market, and process related problems. Specifically, a project team requires effective human interconnections to foster and develop successful products by using the knowledge network of team members [19].

The use of TMS in NPD teams suggests that project team members must utilize each other as an external memory aid to add to and improve their own memories [35]. Essentially, people on the team use their transactive memories to retrieve and combine necessary information to complete the project successfully: a TMS is therefore needed by team members to develop their expertise in a variety of knowledge domains. The TMS helps an NPD project team by:

1. helping members compensate for one another;
2. reducing the cognitive load of each member;
3. providing access to an expanded pool of expertise and information;
4. decreasing redundancy of effort;
5. facilitating sharing and dissemination of tacit knowledge of different knowledge domains; and
6. allocating resources according to member expertise.

Despite the importance of TMS in NPD projects, little research has been attempted on the factors affecting the development of TMS and its impact on project outcomes. For our work, antecedent variables were selected from the group behavior literature and used to test TMSs in a NPD project team context. Many group level studies have demonstrated the significance of team membership stability, trust, collocation, familiarity with each other, and communication [16,64,73].

3. Hypothesis development

3.1. Antecedents

Group/team level studies have noted the importance of team stability on effective TMS development; membership change is low in a stable team, whereas turnover is high in an unstable team. Research on team stability has emphasized the disruption caused by member turnover on functioning and project performance due to knowledge depreciation. For instance, when studying 211 NPD projects, Akgün and Lynn [1] found that team stability had a positive impact on team learning and project success. Further, they suggested that team stability facilitated the development of TMS in stable environments; the team loses a valuable knowledge and information resource when a member leaves the team. However, they did not test this. Moreland et al. [56] also agreed that group instability could disrupt a team's TMS; also new members tend to disrupt the TMS [54]. Further, new team members may disrupt the established beliefs, practices and the existing TMS, because the new information/knowledge brought in may affect collective beliefs and memory structures. Argote and Ingram [5] argued that membership change is harmful when member-task network and member-tool network did not fit the skill and expertise of new members. Bangerter [9] also said that a TMS was sensitive to *member fluctuation*. Therefore, it is hypothesized that:

H₁. Team member stability will be positively related to development of TMSs in NPD project teams.

Trust is another critical factor in effective TMS development. Even though this is a broad topic, consistent with Kanawattanachai and Yoo [39], the interpersonal trust among team members was the focus of our study. McAllister [48] defined interpersonal trust as “the extent to which a person is confident in, and willing to act on the basis of, the words, actions, and decisions of another.” It is multidimensional, involving both cognitive and affective aspects. *Cognitive-based trust* refers to calculative and rational characteristics; it is developed when people do what they promise to do in a timely and professional fashion. *Affect-based trust* involves emotional elements and social skills of trustees,

including care and concern; it denotes the close social relationships of a team.

The impact of trust on TMS is well established in group behavior. Liang et al. [43], for instance, argue that the level of trust and confidence among group members is directly related to the development of a TMS, because a group member has to trust the expertise of others and believe that they are reliable and competent.

The impact of trust on NPD process is also well known. However, even though studies on cross-functional team integration has emphasized the positive role of trust on the development of knowledge networks in general, there is a lack of work on the effect of trust on TMSs in NPD project teams. For instance, Madhavan and Grover [47] pointed out that trust was critical in a cross-functional team, because its lack causes members to withhold information and this hinders the processes of knowledge articulation, internalization, and reflection. Koskinen et al. [41] also noted that the greater the level of trust, the greater the level of accessibility, and the better the chance of knowledge being transferred and shared in the team. Therefore, it is hypothesized that:

H₂. Interpersonal trust will be positively related to development of TMSs in NPD project teams.

Group member proximity is another factor that closely related to development of TMSs in the literature. In particular, studies on virtual groups indicated that co-located teams were better able to develop an effective TMS. Product development and innovation literature has also emphasized the importance of team member proximity. Kahn and McDonough [38] pointed out that team member proximity or co-location fostered easier and more frequent interaction and that functional and mental barriers between departments were broken down, promoting the close interactions needed in NPS activities. Pinto and Pinto [62] argued that proximity was an effective tool in creating team relationships and improving dissemination of tacit knowledge. Allen [3] found that when the distance between individuals was increased to 10 m, there was a 70% reduction in the probability of informal contact. The researchers all suggested that the propinquity of the team members provided for a shared understanding of the team contextual knowl-

edge, thereby helping members directly observe and share experience. Frequent interaction lead to improved accessibility to other team members' knowledge. Therefore:

H₃. Team member proximity will be positively related to development of TMSs in NPD project teams.

Another antecedent of TMS development is team member familiarity, which refers to the degree of prior interaction between of group members [17,28]. Interpersonal knowledge will be intense in highly familiar teams. Studies have indicated that prior experience forms a range of beliefs and that these affected the sharing of information. Gruenfeld et al. [27] found that groups of members already familiar with each other were significantly more successful at sharing than groups of strangers. Littlepage et al. [44], also said: "Prior group experience should facilitate group problem solving through the development of cognitive structures which allow group members to understand the ways in which other members might be able to contribute to the task."

Team member familiarity makes it possible to develop an effective TMS in an NPD project team. Since this reduces uncertainty and anxiety about social acceptance during the project, and promotes interpersonal attraction and cohesiveness, while team members spend little or no time in acquiring members' expertise and knowledge. It also fosters the rapid coordination and integration of team members' efforts and knowledge, and speeds mutual understanding of the effort. Therefore:

H₄. Team member familiarity will be positively related to development of TMSs in NPD project teams.

Group member communication also facilitates the development of a TMS. For instance, Moreland and Myaskovsky [53] demonstrated that providing feedback about individual skills and opportunities to communicate created an effective TMS. Rulke et al. [65] found that informal communication contributed to the creation of knowledge about who knows what.

Team member communication was also an imperative in developing a TMS in NPD project teams; this involved both formal and informal

intra-team interaction [46]. Formal communication was exchange via formal meetings and written documents. Informal communication involved exchange via hallway interactions and after-work socialization. Since product development was a complex process, it required constant control and interaction among team members. As Patrashkova and McComb [61] pointed out, team members may have difficulty in collaborating if the members fail to compensate for each other's perspectives. In this sense, team member communication is a means to facilitate a shared understanding in the team [49,57]. Therefore:

H₅. Team member communication will be positively related to development of TMSs in NPD project teams.

3.2. Consequences

The positive influence of a TMS on group performance is well established in group behavior literature. In TMS studies, Yoo and Kanawattanachai [85] found that a TMS has a positive impact on team performance as shown by profit, ROA, ROE, stock price, and market share. However, team performance measures are numerous in the NPD literature. In our study, performance measures were limited by selecting only the routinely studied items: team learning, speed-to-market, and new product success. *Team learning* is the level of knowledge that the team gains in performing a new product action [45]; *speed-to-market* shows how fast a new product is developed [40]; and *new product success* denotes the market performance of a new product [15]. However, testing the direct impact of TMS on performance outcomes is difficult because the effect is moderated by project and environmental factors. One of the important factors is the *task complexity*; Vakkari [74] stated that, "The complexity of a task is a central feature in determining its performance and consequent information needs."

Thus it depends on our ability to determine the difficulty or uncertainty of the task outcome [75]. There are two types of task complexity [67] due to:

1. *Routines*: The repetitiveness of the elements of tasks. When a task is simple or involves many

repetitions, people can use standard operating procedures and methods to accomplish it [12]. For higher complexity or non-routine tasks, the elements and their interrelations are uncertain or ill-structured and it is difficult to define clear and precise "means to the end" relations.

2. *Knowledge*: Whether the tasks rely on established bodies of knowledge or require new or novel solutions. Tiarniyu [71], for instance, pointed out that a complex task is accompanied by ambiguity and difficulty due to incomplete a priori knowledge about inputs, procedures, and solutions. Complex tasks are new and the information required can seldom be determined in advance.

The complexity of the task may differ from one project to another and the TMS may vary with task complexity, affecting team learning and knowledge enhancing for high complexity tasks. Complexity increases as the number of criteria specified by technical, manufacturing, and marketing requirements increase and as uncertainty about the match between technical ability and market requirements; product development process and environment; and project routines and dynamic or ambiguous information about the market and technology increase. Accordingly, teams are exposed to more stimuli, creating increased arousal and must search for and evaluate alternatives, demanding more information [11,76]. Therefore, more complex tasks call for more cooperation and coordination between team members.

In addition to team learning, the influence of TMSs on speed-to-market depends on the level of task complexity. As noted in the literature, when task complexity increases, team members experience higher cognitive loads and trade off decision accuracy against the time required to make the decision [60]. In essence, the better a team member understands the elements of a task, the easier it is to express what type of information and knowledge is useful and select its source.

Finally, since highly complex tasks put more demand on the team members' knowledge, the success of the product is substantially influenced by the quality of the TMS where team members make decisions about product and process plans and alternatives more effectively and solve product and process related problems more successfully. Therefore:

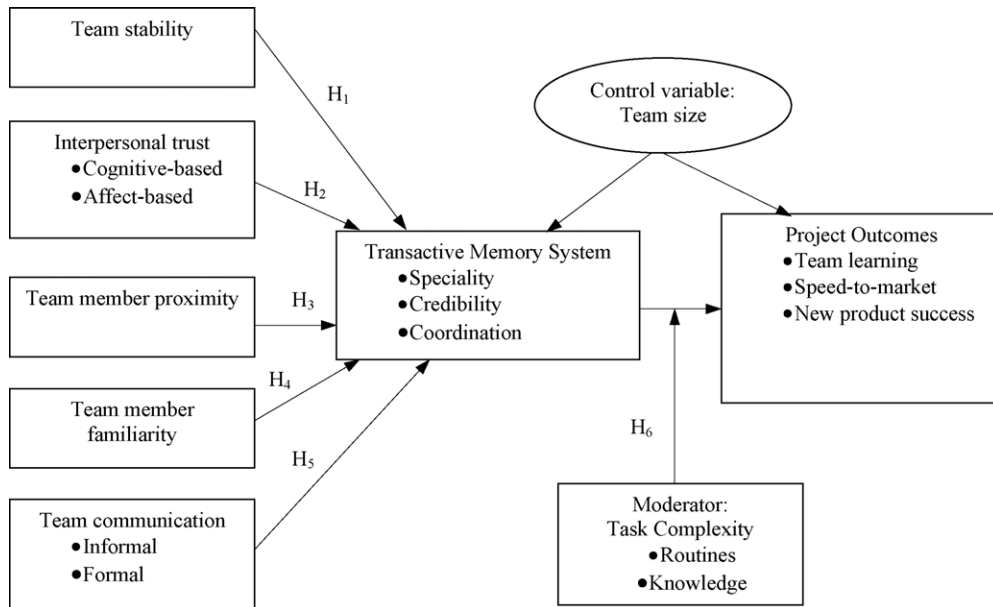


Fig. 1. Proposed model.

H₆. The higher the task complexity, the more of an impact that TMS will have on team learning, speed-to-market, and new product success.

Fig. 1 depicts our hypotheses.

4. Research method

4.1. Sampling

The initial sample consisted of 150 firms in the industrial zone of Turkey, near Istanbul. These firms were selected because they develop new products and export them to other countries; they were identified by the Istanbul and Gebze Chamber of Industry. The general managers of the firms were contacted by telephone and we explained the aim of our study to them. Of the 150 contacted, 80 agreed to work with us; from 27 of these firms, we received usable data describing 69 new product development projects (this is a 34% response rate). Data were not available from some of the project teams due to their small size (less than three persons in the team) and lack of cooperation from some project teams members.

Respondents primarily were product/project managers who had been asked to select projects that were

commercialized and in the marketplace for at least 6 months. After the respondents had been selected, each was told that their responses would be anonymous and that data (individually, their company, or products) would not be disclosed. The respondents were asked to consult with other team members and answer questions in a “round table” format to avoid “key informant bias.” The data collection session took an average of 50 min, which included gathering responses to the 56-question survey instrument and interviewing team members (for some projects, this data collection session took 2 h). Several industries were included: telecommunications, computer and electronics, communication, software, manufacturing and machinery, chemical, service technologies, food, and material. The products were primary consumer durables (33.3%), consumer service (18.6%), industrial materials or parts (37.8%), and industrial service (10.3%).

4.2. Measures

To test the hypotheses, multi-item scales adopted from prior studies were used for the measurement of constructs: thirteen were measured, using a 5-point Likert scales ranging from ‘strongly disagree’ (0) to ‘strongly agree’ (5). Task complexity questions were

asked as itemized rating scale from ‘extremely low’ (0) to ‘extremely high’ (5). By using the parallel-translation method, items were first translated into Turkish by one person and then retranslated into English by a second person. The two translators then jointly reconciled all differences. The suitability of the Turkish version of the questionnaires was then pre-tested using five part-time graduate students working in industry and involved in at least one NPD project. After refining the questionnaire based on interviews with the pre-test subjects, the questionnaires were distributed and collected by one of the authors, using the “personally administrated questionnaire” method. The measures and their sources can be found in the Appendix A. Since a multi-company, multi-industry sample was used, speed-to-market difference in the nature of projects were controlled by using relative speed measures, assessed relative to pre-set schedules, company standards and similar competitive projects. Team size (number of persons) was selected as a control variable because TMS, team learning and speed-to-market, are influenced by the size of the team. In particular, knowing who knows what may not be clear in a large team, because the members may not know each other well, or the degree of all others’ expertise.

4.3. Measure validity and reliability

After collection, data were subjected to a purification process in assessing their reliability, unidimensionality, and discriminant validity [4]. To assess the unidimensionality, measures were divided into four subsets: the three TMS measures (specialization, coordination, and credibility), the three outcome measures (team learning, speed-to-market, and new product success), the antecedents of TMS measures (team stability, team member familiarity, formal team communication, informal team communication, cognitive-based trust, affect-based trust, and team member proximity), and moderator measures (task complexity in the perspective of routines and task complexity in the perspective of knowledge) as recommended by Moorman and Miner [52] and Bentler and Cho [10] due to small sample size. Results indicated that four models fit adequately: the three TMS variables ($\chi^2_{(32)} = 36.2$, $p = 0.28$, RMSEA = 0.04, CFI = 0.97), three outcome variables

($\chi^2_{(51)} = 87.3$, $p = 0.03$, RMSEA = 0.10, CFI = 0.91), antecedent variables ($\chi^2_{(113)} = 161.4$, $p = 0.003$, RMSEA = 0.04, CFI = 0.90), and moderator variables ($\chi^2_{(19)} = 31.8$, $p = 0.03$, RMSEA = 0.04, CFI = 0.92).¹

To assess the discriminant validity, a series of two-factor models, as recommended by Bagozzi et al. [8], were estimated; individual factor correlations, one at a time, were restricted to unity using AMOS 4.0. The fit of the restricted models was compared to those of the original model. The chi-square change ($\Delta\chi^2$) in each model, constrained and unconstrained, were significant, $\Delta\chi^2 > 3.84$, which suggested that the constructs demonstrated discriminant validity.

Further, the measures were subjected to Confirmatory Factor Analysis (CFA) using AMOS 4.0, where all variables, excluding team size variable, were included in one CFA model. For the CFA analysis, subscales or parcels were used instead of individual items (a method aggregating or taking the mean of several items that purportedly measure the same construct as indicators of a latent variable), as recommended by Dragow and Kanfer [21], and Schmit and Ryan [66]. These researchers had noted that goodness-of-fit measures were affected when the number of items used to identify a small number of factors was relatively large. Consistent with this approach, two sub-scores or parcels for each scale were computed, each consisting of a randomly divided subset of the items in the scale. The CFA produced a good fit with an incremental fit index (IFI) of 0.91 and a comparative fit index (CFI) of 0.90 (also, $\chi^2_{(302)} = 396$, RMSEA = 0.07).

A second-order confirmatory factor analysis of a model depicting the specialization, credibility, and coordination was conducted because the first-order factors loading onto a single transactive memory system factor included fifteen observable variables (reflecting three latent factors). This model also yielded acceptable fit indices ($\chi^2_{(34)} = 36.3$; $p = 0.36$, CFI = 0.98; IFI = 0.98; RMSEA = 0.03). In addition, all first-order and second-order factor loadings were significant, thereby providing evidence for the plausibility of the thesis that a TMS is a multifaceted construct construed from specialization, credibility, and coordination.

¹ Confirmatory factor analysis item-construct loadings can be obtained from authors.

Table 1
Descriptive scales and construct correlations, and reliability estimates

Mean	S.D.	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3.67	0.59	1 NPS	–															
3.61	0.85	2 Speed-to-market	0.31***	–														
3.71	0.61	3 Team learning	0.35***	0.03	–													
3.96	0.54	4 TMS—specialization	0.42***	0.15	0.24**	–												
4.02	0.55	5 TMS—credibility	0.18	0.22*	0.04	0.26**	–											
3.86	0.62	6 TMS—coordination	0.37***	0.29**	0.28**	0.29**	0.30***	–										
4.06	0.86	7 Team stability	0.41***	0.42***	0.43***	0.26**	0.14	0.42***	–									
3.63	0.91	8 Familiarity	0.32***	0.26**	0.21*	0.22*	0.37***	0.27**	0.19	–								
3.44	0.78	9 Formal communication	0.21*	–0.07	–0.07	0.17	–0.08	–0.09	–0.04	0.02	–							
3.48	0.94	10 Informal communication	0.11	0.11	0.13	–0.09	–0.09	–0.11	0.04	0.13	0.23**	–						
3.96	0.54	11 Cognitive-based trust	0.23*	0.13	0.37***	0.11	0.45***	0.54***	0.29**	0.44***	0.02	0.04	–					
3.87	0.50	12 Affect-based trust	0.16	0.39***	0.08	0.13	0.45***	0.32***	0.27**	0.35***	0.07	0.28**	0.50***	–				
2.81	1.0	13 Proximity	–0.02	0.03	0.13	0.08	–0.07	–0.02	0.16	0.16	0.19	–0.11	0.18	–0.07	–			
3.29	0.78	14 Task complexity—routine	0.04	0.09	0.08	0.03	0.02	0.14	0.11	0.14	0.08	0.04	–0.04	–0.05	0.08	–		
2.87	0.69	15 Task complexity—knowledge	–0.18	–0.19	–0.05	–0.10	0.03	–0.08	–0.14	0.06	–0.13	0.24**	0.04	–0.03	–0.02	–0.07	–	
–	–	16 Team size	0.03	0.12	–0.11	0.24**	0.04	0.23**	–0.05	–0.23	0.12	0.06	–0.29**	–0.11	–0.08	0.23*	–0.3	
		Variance extracted	0.78	0.51	0.58	0.44	0.67	0.49	0.69	0.59	0.62	0.78	0.54	0.49	0.54	0.74	0.68	–
		Comp. reliability	0.87	0.79	0.73	0.62	0.80	0.66	0.81	0.71	0.76	0.88	0.70	0.66	0.64	0.85	0.81	–
		Cronbach's α	0.87	0.86	0.77	0.60	0.78	0.63	0.70	0.87	0.75	0.86	0.71	0.62	0.84	0.78	0.77	–

Table 1 shows the correlation among all sixteen variables. The relatively low to moderate correlations provided further evidence of discriminant validity. Also, all reliability estimates, including coefficient alphas, average variance extracted for each construct, and AMOS-based composite reliabilities, were well-beyond the threshold levels suggested by Nunnally [59] and Fornell and Larcker [24]. In addition, the squared correlations (ranging from 0.0004 to 0.30) did not exceed the average variance extracted (ranging from 0.44 to 0.78) further suggesting discriminant validity. It was therefore concluded that measures were unidimensional and had adequate reliability and discriminant validity. Further, skewness ranged from -1.11 to 0.33 , and kurtosis ranged from -1.02 to 3.06 . These results indicated that the variables were well below the level requiring transformation of variables (skewness of 2 and kurtosis of 5 as indicated by Ghiselli et al. [25]).

5. Analysis and results

A series of multiple linear regression models were performed. The mean of items (composite score) was used for each variable. Table 2 demonstrates the results of the antecedents of TMS in NPD teams. As shown there, each TMS construct was regressed on the independent variables. The results indicated that, when specialization was selected as the dependent variable, the model was not significant. When

credibility was selected as the dependent variable, it was found that affect-based trust was the only significant predictor. Team stability and cognitive-based trust were significant predictors when coordination was selected as a dependent variable. Second, the components of TMS were summed as one cumulative construct of TMS for the project teams. Results showed that team stability, cognitive-based trust, affect-based trust, and team member familiarity were significant predictors of TMS, supporting H_1 , H_2 , and H_4 . However, statistical support was not found for team member proximity and team communication, thus H_3 and H_5 were not supported.

In order to assess the moderator role of task complexity between TMS and project outcomes, a split group analysis was performed by dividing the sample into low and high task complexity via a median split. Following standard practice, Chow tests were performed to determine whether the models based on the split samples were significantly different from each other [69]. Specifically, regressions were performed on the four subsamples defined by the models, high and low task complexity (routines and knowledge). The regression coefficients from high and low conditions were then compared using a *t*-test. As shown in Table 3, the impact of TMS on team learning was significant under the conditions of low task complexity in the perspective of routines and high task complexity in the perspective of knowledge. Comparing regression coefficients in low-task complexity and

Table 2
Results

Independent variables	Hypothesis	TMS—specialization, beta	TMS—credibility, beta	TMS—coordination, beta	TMS—cumulative, beta
Team stability	H_1	0.22*	-0.05	0.31***	0.23**
Cognitive-based trust	H_2	-0.17	0.17	0.46***	0.23*
Affect-based trust	H_2	0.11	0.35**	0.03	0.22*
Team member proximity	H_3	-0.02	-0.12	-0.17	-0.15
Team member familiarity	H_4	0.19	0.19	0.07	0.21*
Formal team communication	H_5	0.27**	0.008	-0.03	0.11
Informal team communication	H_5	-0.08	-0.08	-0.16	-0.15
Team size		-0.13	-0.04	0.11	-0.02
<i>F</i>		1.54	3.47***	4.80***	4.89***
R^2_{adj}		0.17	0.32	0.39	0.32

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

Table 3
Regression coefficients under the different complexity conditions

Regression line	Task complexity—routine			Task complexity—knowledge		
	Low (it is a routine task)	High (it is not routine task)	<i>t</i> -value	Low (tasks rely on established bodies of knowledge)	High (tasks do not rely on established bodies of knowledge or require newer, novel solutions)	<i>t</i> -value
TMS → team learning	0.12* (0.29)	0.11 (0.15)	0.23	0.04 (0.06)	0.15** (0.36)	3.67***
TMS → speed-to-market	0.13 (0.26)	0.64*** (0.59)	10.85***	0.30 (0.32)	0.24** (0.41)	1.5
TMS → NPS	0.19*** (0.47)	0.32*** (0.52)	4.48***	0.13** (0.43)	0.37*** (0.52)	2.45**
Sample size	42	20		27	34	

Standardized values are in parentheses. Team size used as a control variable in all regression analyses.

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

high-task complexity conditions showed that low and high task complexity from the perspective of routines was not significant. However, regression coefficients between low and high task complexity, from the perspective of knowledge, was significant, indicating that task complexity increased the impact of TMS on team learning. Thus, H_{6a} was partially supported. Table 3 also demonstrates that the impact of TMS on speed-to-market was significant in all types of conditions, except for the low task complexity, from a perspective of knowledge. Comparison of the regression coefficients indicated that the coefficients of low and high task complexity in the perspective of routines were statistically significant, whereas low and high task complexity from the perspective of knowledge coefficients was not significant. Thus, our H_{6b} was partially supported. Finally, the impact of TMS on NPS was significant under all types of conditions. Comparison of the regression coefficients between low and high task complexity was significant, indicating that task complexity increased the impact of TMS on NPS. Thus, H_{6c} was supported.

6. Discussion and conclusions

Antecedents and consequences of TMS in NPD project teams were investigated. Our findings demonstrated that an effective TMS occurs in an NPD project team when team members remain on the team from pre-prototype through launch of product development process, rely on other members when they do their jobs, approach their tasks with professionalism and

dedication, talk freely to other members about project related issues and respond constructively and caringly, and develop an emotional ties in their working relationship. In addition, when team members knew each other and had prior personal interaction at the time the project team was formed, the TMS was developed sooner.

Interestingly, even though group behavior literature has noted the importance of communication and proximity for TMS development [37], our study did not find statistical support of the importance of these aspects on the development of TMS in project teams.

This study also tested the impact of TMSs on project outcomes, such as team learning, speed-to-market, and new product's success in the market place. The bi-variate correlations demonstrated that TMS has a positive association with team learning, speed-to-market, and NPS. This was of particular note when teams established an effective TMS, as the project team, develops the new product with fewer technical problems, finds and solves the product problem areas with which customers were dissatisfied, and develops and launches product faster and better. However, it should also be noted that the impact of TMSs on project outcomes is contingent upon the project's complexity; when the tasks rely on established bodies of knowledge, and there is a clearly defined way to do the major types of project's work, the impact of TMS on team learning, speed-to-market and NPS will be less. Also, when the repetitiveness of the elements of project's tasks is low—team members' work is non-routine, the impact of TMS on speed-to-market and NPS will be higher. Non-routine work requires a socially distributed knowledge network more than

routine work, because less repetition of the elements of project's tasks requires team members to ask other people to deal with emerging new information and knowledge.

7. Managerial implications

Implications for managers are three-fold. First, they should enhance a TMS during the project. If people cannot gain timely and unobstructed access to others, who have the needed experience and skills, knowing who knows what just remains idle information. Developing and sustaining a TMS is imperative for project performance. Second, managers should discourage team member turnover and facilitate trust among the members. Also, they should support formal and informal, within team communication at the start of the project. Third, managers should tie IT and the TMS together for effective project management.

8. Limitations

There are some methodological limitations to this study, notably, retrospective reporting and cross-sectional research design. Because there was a time lag between projects completion and data collection, there might have been a recall issue in survey questions. However, the responses of most of the team members were used to diminish this effect and to improve objectivity. It should be noted that Miller et al. [50] suggested that the use of retrospective data is acceptable if reported measures are reliable and valid. The measures used in our research demonstrated both reliability and validity, and most of the measures were well established in the literature.

Utilizing a cross-sectional design with questionnaires was also a limitation of this study. Even though "surveying is a large and growing area of research in the natural environment" [26], the method used may not provide objective results about the flow of knowledge, which is an inherently dynamic phenomena, in NPD teams. A research strategy that may overcome this limitation is one that involves longitudinal studies, in which flow of knowledge can be followed over time. Also, using the perceptions of respondents, i.e., subjective measures, may not

indicate the objective results. Even though moderate to high correlations were found between subjective and objective measures (e.g., 0.69 in Dess and Robinson [18]), using objective measures, archival data for some variables, such as speed and success, may give results that are more objective.

In addition, the study was conducted in a specific national context, Turkish NPD teams. For instance, Turkish culture demonstrates more collectivist (less individualistic) activity than most Western cultures and "social belonging" to groups and teams is high in Turkish culture. Thus readers should be cautious when generalizing the results to a different cultural context [31].

In addition, there are some theoretical limitations. The behavioral aspects of the use of TMS were not investigated. From a behavioral perspective, a TMS fosters a shared vision, common goals, teamwork and mutual understanding for project teams [82]. TMSs also foster team *creativity* and thereby may lead to the development of new and novel products [70]. However, there are issues of common concern regarding the behavioral aspect in the use of TMS; e.g., in some cases, team members are not willing to share information/knowledge.

In our study, the impact of TMSs on team learning, speed-to-market, and NPS was tested. However, using these dependent variables may not capture the whole aspect of NPD projects. Other depended variables, such as product quality, process proficiency and project cost, could also be considered. Also using different moderating factors, e.g., environmental turbulence, newness of product to firm and industry, and organizational culture; special types of work groups (e.g., new software development teams); and industries (e.g., telecommunication industry) could be investigated in the context of antecedents and consequences of transactive memory system.

Appendix A. Measures

A.1. *Transactive memory system (adapted from Lewis [42])*

A.1.1. *Specialization*

- Each team member has specialized knowledge of some aspect of our project.

- I have knowledge about an aspect of the project that no other team member has.
- Different team members are responsible for expertise in different areas.
- The specialized knowledge of several different team members was needed to complete the project deliverables.

A.1.2. Credibility

- I was comfortable accepting procedural suggestions from other team members.
- I trusted that other members' knowledge about the project was credible.
- I was confident relying on the information that other team members brought to the discussion.

A.1.3. Coordination

- Our team worked together in a well-coordinated fashion.
- We accomplished the task smoothly and efficiently.
- There was much confusion about how we would accomplish the task (reversed).

A.2. New product success (adapted from Cooper and Kleinschmidt [15])

This product:

- met or exceeded sales expectations;
- met or exceeded profit expectations;
- met or exceeded return on investment (ROI) expectations;
- met or exceeded senior management's expectations;
- met or exceeded market share expectations;
- met or exceeded customer expectations.

A.3. Speed-to-market (adapted from Kessler and Chakrabarti [40])

- Was completed in less time than what was considered normal and customary for our industry.
- Was launched on or ahead of the original schedule developed at initial project go-ahead.
- Top management was pleased with the time it took us to full commercialization.

A.4. Team learning (adapted from Lynn et al. [45])

- Post-launch, this product had far fewer technical problems than our nearest competitor's product or our own previous products.
- Overall, the team did an outstanding job uncovering product problem areas with which customers were dissatisfied.
- Overall, the team did an outstanding job correcting product problem areas with which customers were dissatisfied.

A.5. Team stability (adapted from Akgün and Lynn [1])

- The project managers who started this project remained on from pre-prototype through launch.
- Department managers who were on the team remained on it from pre-prototype through launch.
- Team members who were on the team remained on it from pre-prototype through launch.

A.6. Team member familiarity (adapted from DeChurch and Marks [17])

- I knew the other members of my team (on average), at the time our project team was formed.
- I had interaction with the other members of my team (on average), at the time our project team was formed.

A.7. Formal team communication (adapted from Lynn [46])

- Team members conducted frequent formal communications through team meetings with fellow project team members.
- Team members conducted frequent formal communications through memos with fellow project team members.

A.8. Informal team communication (adapted from Lynn [46])

- Team members conducted frequent informal communications at water cooler/coffee maker with fellow project team members.

- Team members conducted frequent informal communications at launch or after work with fellow project team members.

A.9. Team member proximity (adapted from Kahn and McDonough [38])

- The core engineers on this team were located within a short walk of the core marketers.
- The core engineers on this team were located so close to the core marketers that they could talk to one another without using a telephone.

A.10. Cognitive-based trust (adapted from Kanawattanachai and Yoo [39])

- Most of my teammates approach his/her job with professionalism and dedication.
- I see no reason to doubt my teammates' competence and preparation for the job.
- I can rely on other teammates not to make my job more difficult by careless work.
- Most of my teammates can be relied upon to do as they will do.

A.11. Affect-based trust (Adapted from Kanawattanachai and Yoo [39])

- I can talk freely to my team about difficulties I am having at work and know that my team will want to listen.
- If I share my problems with my team, I know s(he) would respond constructively and caringly.
- I would have to say that we (my team) have made considerable emotional investments in our working relationship.

A.12. Task complexity—routines (adapted from Scott and Tiessen [67])

- To what extent would you say your work is routine?
- To what extent are your duties repetitious?
- To what extent do co-workers perform repetitive activities in doing their jobs?
- To what extent do your co-workers do about the same job in the same way most of the time?

A.13. Task complexity—knowledge (adapted from Scott and Tiessen [67])

- To what extent is there a clearly defined way to do the major types of work you normally encounter?
- To what extent is there a clearly defined body of knowledge of subject matter which can guide you in doing your work?
- To what extent is there an understandable sequence of steps that can be followed in doing your work?
- To do your work, to what extent can you actually rely on established procedures and practices?

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