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Exploring the Role of Dynamic Capabilities of Information System Development Project Teams

Jack Shih-Chieh Hsu

Tung-Ching Lin

Shih-Yu Wang

Chiou-Mei Chen

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Jack Shih-Chieh Hsu
National Sun Yat-Sen University
jackshsu@mis.nsysu.edu.tw

Tung-Ching Lin
National Sun Yat-Sen University
tclin@mis.nsysu.edu.tw

Shih-Yu Wang
National Sun Yat-Sen University
d014020006@student.nsysu.edu.tw

ABSTRACT

The increasingly dynamic external environment serves as one risk factor which undermines information system development (ISD) project performance. This highlights the importance of ISD teams having certain capabilities to respond to the external variations. In this study, we proposed that ISD teams can better react to external changes and achieve goals if they have sufficient dynamic capabilities: a combination of market/environment orientation, absorptive capacity, coordination capability and collective mind. We also proposed that a team has stronger dynamic capabilities when team members possess complementary expertise and know the expertise and tasks of others. In addition, after examining the moderating effect of knowing the expertise and tasks of others on the relationship between complementary expertise and team dynamic capabilities, we found that complementary expertise can substitute for knowing the location of expertise and complements knowing the tasks of others. Based on the results, implications for academia and practitioners are also provided.

Keywords: Team dynamic capabilities, information systems development project, expertise complementary, team mental model, transactive memory

INTRODUCTION

Rapid changes and highly uncertain business environments drive many organizations to plan projects for accomplishing particular tasks. Projects are temporarily composed of teams to perform work, for instance, an information system development (ISD) project team, which might consist of system analyst, developers, and project manager. An unstable, constantly changing environment serves as one critical risk factor in an ISD project (Wallace et al. 2004). Low project performance is observed when the ISD team cannot effectively react to technical or business changes resulting from globalization or economic turbulence (Hsu et al. 2008; Nidumolu 1995). It is therefore important for project teams to be flexible so they can effectively and efficiently react to business and technical changes (Lee et al. 2005). Project team outcomes are expected to be particularly good when teams are highly flexible.

Several recent studies have shown that being able to react to requirement and technology changes can enhance project performance (Lee et al. 2005; Li et al. 2010). However, what drives project teams to be flexible remains unclear. To further investigate this issue, we take a capability perspective and view being able to react to external changes as one type of capability. We argue that understanding the capabilities that project teams possess can better explain why some teams can perform better than others. Specifically, we adopted the dynamic capabilities proposed by Pavlou and El Sawy (Pavlou et al. 2006) and applied them to the ISD context. We expect that higher performance can be achieved when teams are able to sense external changes, absorb external resources, coordinate with each other, and form a collective mind. The objectives of this study are therefore to (1) explore the effect of team dynamic capabilities in ISD projects, and (2) if team dynamic capability is one critical determinant of project performance, we also want to know the antecedents of team dynamic capabilities, guided by the following research questions:

RQ1: Do teams with better dynamic capabilities perform better than those without?

RQ2: Why do some teams have stronger capabilities than others?

In particular, we study the dynamic capabilities issue from the perspective of expertise. An ISD project is a knowledge intensive process in which different types of expertise are required to ensure high project performance (Mitchell 2006). For example, developers require knowledge from many distinct subjects when communicating with users in order to reduce the problem of incorrect requirements (Hsu et al. 2012). Therefore, expertise is one of the most important resources of an ISD project. Project teams are expected to have stronger dynamic capabilities when members possess sufficient expertise. Specifically, the various kinds of expertise possessed by individuals have to complement each other to generate a greater effect.

In the next section, we introduce team dynamic capabilities and their role in ISD projects. We then develop hypotheses based on the resources-to-capabilities concept. In the third section, the method used to collect required data to examine the proposed model is described. The fourth section presents the analysis results and relevant discussions. The article ends with a conclusion and implications.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Team dynamic capabilities

"Dynamic capabilities" are defined as the ability to address rapidly changing environments through integrating, building and reconfiguring internal and external resources (Eisenhardt et al. 2000; Teece et al. 1997). Pavlou and El Sawy (Pavlou et al. 2006) pointed out that to react to a dynamic environment, new product development teams should be able to scan market trends, coordinate with each other, absorb external knowledge and form a collective mind. They then proposed that dynamic capabilities include marketing orientation, absorptive capacity, coordination capability and collective mind. In a similar manner, to be viewed as having sufficient dynamic capabilities, ISD team members should be able to scan and identify changes, identify required knowledge resources and acquire required but absent resources, and coordinate with each other to form new expertise or adjust themselves to a new condition for countering changes. We therefore adopted the concept suggested by Pavlou and El Sawy (Pavlou et al. 2006) and argue that the dynamic capabilities of an ISD project team should include those concepts. Furthermore, we extended the market orientation with environment orientation given that, in addition to understanding the clients or users of the developed system, ISD project teams also need to know changes in stakeholders or changes caused by other stakeholders. Therefore, the dynamic capabilities of ISD project teams include market/environment orientation, absorptive capability, coordination, and collective mind. The research model is shown in Figure 1. In the followings, we introduce each capability individually.

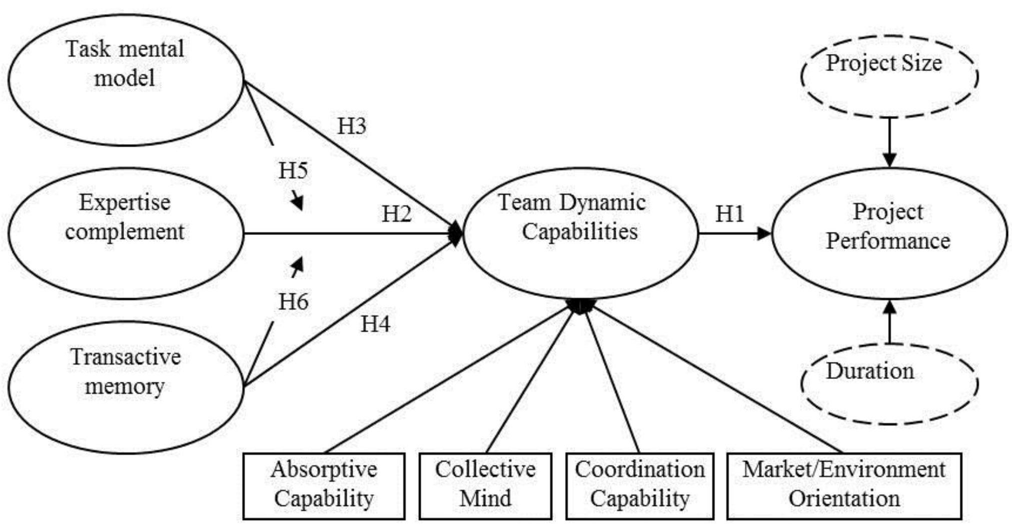

Figure 1. The Proposed Research Model

Market/Environment Orientation

In a turbulent environment, requirement uncertainty is high and changes to the system design are frequent. In this context, the ability to sense environmental changes is needed so that project teams can immediate take action to manage those environmental changes. In order to understand possible changes, high performance project teams, in general, perform activities to acquire and identify key information related to the company's operations (Aguilar 1967; Milliken 1990). This information addresses surrounding issues such as competition, regulation, technical changes and market needs. With the above information, project teams can diagnose possible opportunities and threats, and then reconfigure internal and external resources (Teece 2007). Given its importance to final performance, this construct has received significant attention. For example, Pavlou and El Sawy (Pavlou et al. 2006) highlighted the need to be market oriented in a new product development context. In this study, we followed the perspective of Pavlou and El Sawy (Pavlou et al. 2006) and defined market/environment orientation as the ISD team members' ability to scan and identify changes, focusing on events occurring outside of the team workspace that may influence teamwork (Steinfield et al. 1999).

Absorptive Capacity

Absorptive capacity is defined as the ability to recognize valuable external information and then acquire, assimilate and utilize that new knowledge (Cohen et al. 1990). This also requires team members to interrelate their expertise with the expertise of other team members. Therefore, team members should be not only capable in their individual area but also familiar with the expertise of others within the team (Tiwana et al. 2005). Team members with high absorptive capacity can effectively acquire and assimilate new knowledge, and then transform and exploit it to learn and respond more quickly to changes. The lack of absorptive capacity impedes knowledge transformation and makes team members unable to assimilate, internalize and utilize the knowledge (Joshi et al. 2006). Thus, absorptive capacity is an important dynamic capability which allows the team to react to change in a turbulent environment.

Coordination Capability

Coordination capability refers to the ability to manage interdependencies (Malone et al. 1994). In a teamwork context, task interdependence is highly emphasized. Coordination, communication and negotiation are needed in order to complete the tasks when members' goals, outcomes and resource needs are mutually dependent (Zhang et al. 2007). That is, the team should be able to manage interdependent resources and expertise effectively through coordination (Faraj et al. 2000). The task structure changes when requirements or technologies change. For example, new functions may be added and existing functions may be removed when requirements are changed. In addition, new members familiar with new technologies may be added to the project team. Adding or removing resources also changes the interdependencies and, therefore, in order to respond to constantly changing environments, teams must exercise effective coordination, including reassigning tasks, reallocating resources and reorganizing outputs (Faraj et al. 2000). Nidumolu (Nidumolu 1995) also indicates that project teams without sufficient coordination capabilities are unable to counter risks resulting from unstable requirements and technological uncertainties. Therefore, coordination is one important element for ISD teams to possess in order to deal with dynamic environments.

Collective Mind

Weick and Roberts (Weick et al. 1993) define "collective mind" within a group as a social system in which members heedfully interrelate their actions. It includes actions that are constructed by actors in the system (contribution), actions connected by themselves and others to form actors' understanding (representation), and the interrelation of actions within the system (subordination). By viewing the ISD team as a system, members with collective mind would understand how their contributions impact the project outcome, form a shared understanding of the team's tasks (which can save time checking and asking what other members are likely to do), consider that the goals of the team are more important than individuals' goals, and further improve team performance (Crowston et al. 1998). In order to react to external changes, the ISD team has to form a consensus in which team members consider how their actions affect others and know how their expertise is connected together within the team. They have a common view of the project and will not act only according to their individual minds (Akgün et al. 2006). With the collective mind, team members can effectively communicate with each other to resolve conflicts. In contrast, for an ISD team without the collective mind, members' actions and decision are not aligned. Conflicts are unavoidable, lowering teamwork moral. Thus, collective mind is an essential dynamic capability for ISD teams.

As indicated above, those capabilities reflect the extent to which project teams can effectively respond to challenges. Project performance is expected to be higher when teams are able to (1) sense external changes and understand how those changes will affect project execution, (2) absorb resources which are absent within the team but needed to counter environmental turbulence, (3) coordinate with each other to manage interdependences in order to react to changes, and (4) form a collective mind about the new status so that they can take mindful actions. We therefore propose:

H1: Project performance is associated with team dynamic capabilities.

Critical Resources for Forming Dynamic Capabilities

Expertise Heterogeneity

A project team is a collection of individuals with diversified and required expertise (Tiwana et al. 2005). Diversity can be viewed as an aggregation of various heterogeneous resources and competencies which members require of each other while performing tasks. Project performance drops significantly when the team does not have the required expertise (Barki et al. 1993; Jiang et al. 2000). For example, to complete an ISD project requires knowledge in multiple technical and functional domains (Curtis et al. 1988; Walz et al. 1993). In the absence of either or both of these domains, the final system cannot fit the business requirements, or may not be accomplished at all. One of the most important antecedents of team dynamic capabilities is having heterogeneous expertise within the team. The construction of a team with varied and complementary backgrounds and experiences not only guarantees diverse viewpoints but also brings different sets of skills, perspectives, and knowledge to the project. The team can develop a more comprehensive view of the changes, generate a wealth of potential solutions, and implement the selected solutions. Having sufficient expertise increases the chance that the team is capable of identifying external changes and absorbing external knowledge. In a turbulent environment, each minor change requires individuals with special expertise to detect it. More changes—and their causes—can be detected and analyzed when at least one member has expertise in that area. Moreover, if the team's members have similar backgrounds and experiences, they may be unable to generate a comprehensive understanding of the changes at hand because only one perspective is adopted. After detecting changes, different types of expertise are needed to form appropriate reaction plans. Members need to obtain specific expertise from external resources when it is absent from the team. Diversified expertise is critical at this stage since individuals who possess specialized knowledge often act as magnets bringing outside expertise to the project team (Curtis et al. 1988). Therefore, we propose:

H2: Team dynamic capabilities are positively associated with expertise complementarity.

As indicated above, in order to be able to react to a dynamic external environment, ISD team members should first sense external changes, then acquire and transform available knowledge to a usable form, coordinate with each other, and react to external changes collectively. During these processes, on the one hand, tasks should be reorganized and restructured and, on the other hand, expertise from internal or external resources should be coordinated or transformed to form usable expertise. Both of the above actions should be taken in order to effectively react to external changes. Therefore, in addition to securing heterogeneous complementary expertise, which represents having the required diversified expertise, we also suggest that further conditions must be built for expertise to be utilized to ensure project performance. In this study, we focus on two major team cognitions identified by teamwork studies: transactive memory and task mental model (e.g., He et al. 2007). We argue that transactive memory allows a team to coordinate and transform expertise efficiently and the task mental model facilitates task reorganization in order to react to changes.

Knowing the Tasks of Others: Task Mental Model

A team contains a number of individuals with heterogeneous or complementary expertise. In an ISD team, individuals perform tasks assigned to them individually and collectively. Members need to know the interdependencies between tasks in order to understand how to avoid possible interference with teamwork, or enhance the efficiency of project execution. We therefore suggest that team members should know which tasks are performed by others, in addition to knowing the expertise possessed by others, so that a team can perform tasks efficiently. Knowing the tasks of the whole project, and the assignment of those tasks, has long been considered a component of team cognition which is critical for teamwork performance. Cannon-Browser and Salas (Cannon-Bowers et al. 1993) call it the "shared task mental model" which refers to knowing the various tasks performed by individuals on the team, and the relationships between those tasks. Knowing the tasks performed by the whole team contributes to team dynamic capabilities in many ways. For example, members in a highly interdependent context need to coordinate with each other intensively. The successful completion of the team project requires individuals to take others' tasks into consideration while performing their own tasks. Members of the same team who understand the tasks can predict the behavior and resource needs of others more accurately (Cannon-Bowers et al. 1990). The maturity of the task mental model within a team is one critical determinant of coordination and collective mind. Therefore, we hypothesize:

H3: Team dynamic capabilities are positively associated with task mental model.

Knowing the Expertise of Others: Transactive Memory

Transactive memory refers to the extent to which members of a team know where to find their required sources of knowledge and how to identify which expert possesses which knowledge(Faraj et al. 2000). It is similar to the *team mental model* which is defined as the shared understanding of the knowledge, skills and abilities possessed by others in the same team (Cannon-Bowers et al. 1993). Transactive memory, or the team mental model, emerges as a collective understanding of member-to-expertise associations, and functions as a collective knowledge resource providing information required for its members to complete a joint task (Hollingshead 1998; Wegner 1987; Wegner 1995). Transactive memory has been applied in some team studies to predict team performance in a laboratory experiment context (e.g., Austin 2003; Ellis 2006; Hinsz et al. 1997; Kanawattanachai et al. 2007; Liang et al. 1995; Zhang et al. 2007). It contributes to team dynamic capabilities by allowing team members to better coordinate their expertise. Knowing the location of expertise is fundamental to expertise coordination in software development teams because it facilitates efficient sourcing of required expertise (Faraj et al. 2000). Whether existing expertise can be coordinated and transformed into usable expertise is contingent on how well team members are aware of the locations of each others' expertise (Griffith et al. 2003). Teams with mature transactive memory have a direct line to sourcing specializations, resources and any information they may require (Stasser et al. 1995). Transactive memory has been shown to have an effect on forming the collective mind (Yoo et al. 2001). Thus, when an ISD team creates a good mechanism for knowing who has what knowledge/skill and where that knowledge/skill resides, it will enhance the effectiveness with which the team can coordinate team members and transform available expertise into usable forms to counter external changes. Based on the above statements, we propose:

H4: Team dynamic capabilities are positively associated with transactive memory.

Moderating Role of Transactive Memory and Task Mental Model

In addition to the direct effect of expertise complementarity, the transactive memory system, and the task mental model, we also proposed the moderating effects of transactive memory and the task mental model. Specifically, we argue that both transactive memory and the task mental model can increase the effect of expertise complementarity on forming team dynamic capabilities.

As we argue above, complementary expertise allows members to better sense external changes and absorb expertise from external sources, both of which are parts of a team's dynamic capabilities. In this section, we argue that heterogeneous expertise can generate a greater effect when members know the location of that expertise. Although diversified expertise alone allows the ISD team to sense external changes and facilitate external resource absorption, coordination and the formation of the collective mind may not take place simply because diversified expertise is present. In fact, diversified and complementary expertise may reduce the efficiency of coordination if transactive memory is absent. This is because even when diversified and complementary expertise are present, a lack of knowledge of the location of that expertise not only increases the cost of searching for the required expertise but also reduces the effectiveness of expertise exchange and integration. As a result, expertise exchange and integration cannot be done efficiently without knowing the sources of the required knowledge (Faraj et al. 2000). In contrast, knowing who has what knowledge allows members to better coordinate expertise by reducing the cost of identifying the location of expertise (Faraj et al. 2000). Members with diversified expertise are able to coordinate with each other more efficiently when members know the location of required expertise. Therefore, we hypothesize:

H5: The relationship between expertise complementarity and team dynamic capabilities is contingent on the magnitude of transactive memory.

In addition to the complementary role of transactive memory on the effect of expertise complementarity, we also proposed that the task mental model has a similar effect. This implies that project teams with a mature task mental model can have better dynamic capabilities. In the previous section, we argued that knowing the tasks of others allows members to coordinate with each other and form a collective mind more easily. Since all members have a clear understanding of the tasks performed by the whole team, when a task needs to be changed because of external uncertainty, teams can better reorganize and restructure task assignments to react to external changes. Individuals in the same team may view problems from different perspectives, which may lead to conflict and time wasting (Pelled et al. 1999). We argue that an even better effect can be achieved when members have a shared understanding of the tasks that they are performing. This is because the reorganization of the content and assignment depends largely on both knowledge of the task and knowledge of the expertise. Members in a team without a shared understanding of their tasks have to spend more time coordinating and forming a collective mind. Therefore, a positive coefficient of the interaction between task mental model and expertise complementarity is expected.

H6: The relationship between expertise complementarity and team dynamic capabilities is contingent on the magnitude of the task mental model.

RESEARCH METHOD

Data Collection

A survey was conducted to examine the proposed hypotheses. We adopted a two-step approach to collect the required data. First, we sent a letter to all 359 members of the Information Management Association (IMA) in Taiwan. The IMA is an organization that aims at improving IT usage and enhancing communication among IS professionals. Almost every member of this organization is an IS department manager. Members who were willing to participate in our study were then contacted by telephone. On the phone, we introduced the major purpose of this study and detailed the data collection procedures. Then each member provided a list of possible participants in his/her department, such as project managers, project members, or team leaders. In the second stage, we delivered the survey package to 750 participants. A total of 215 people returned the survey package, yielding a valid response rate of 28.67%. Table 1 gives the profiles of the respondents. Since obtaining population information is difficult, the representativeness of our sample is assured through comparing with published studies in this area (e.g. Hsu et al. 2012).

Industry	**# of response**	**Percent**	**Team Size**	**# of response**	**Percent**
Manufacturing	63	29.3%	< 3	30	14.0%
Financial	35	16.3%	4~6	55	25.6%
Information Technology	64	29.8%	7~9	82	38.1%
Service	50	23.3%	10~12	35	16.3%
Government	3	1.4%	12 <	13	6.0%
Team duration	**# of response**	**Percent**	**Education**	**# of response**	**Percent**
Under half year	29	32.89%	High school	1	0.5%
Half year ~1 year	59	35.52%	College (2 years)	34	15.8%
1 year ~ 2 years	64	30.26	College (4 years)	131	60.9%
Over 2 years	53	1.32%	Graduate school	49	22.8%
Related Work Experience (years)	**# of response**	**Percent**	**Age**	**# of response**	**Percent**
< 1	35	10.38%	~29	28	13.0%
1~5	93	27.59%	30~39	84	39.1%
6~10	89	26.41%	40~49	73	34.0%
11~15	78	23.15%	50~59	20	9.3%
16~20	39	11.57%	60~	10	4.7%
>20	3	0.89%	**Gender**	**# of response**	**Percent**
			Male	163	75.8%
			Female	52	24.2%

Table 1. Profile of Respondents

Constructs and Measurement

The overview of constructs is shown in Table 2.

Construct	Definition	Source of items
Project performance	The extent to which a project team accomplishes system development tasks efficiently and effectively.	(Guinan et al. 1998; Henderson et al. 1992; Jones et al. 1996)
Expertise complementarity	The capability, experience, knowledge and skill of various heterogeneous experts fitting well within a team.	(Tiwana et al. 2005; Zhang et al. 2007)
Transactive memory	An ideal situation in which a team's members know where to find their required sources of knowledge and how to identify which expert possesses which knowledge.	(Faraj et al. 2000)
Task mental model	The state in which a team member knows not only his or her own task but also the tasks performed by other members of the whole project team.	(Lee et al. 2003)
Market/Environment orientation	The ability to effectively sense environmental changes occurring outside of the workspace that may influence teamwork.	(Pavlou et al. 2006)
Absorptive capacity	The ability of the members of a team to interrelate—in a project context—to the expertise of their peers outside of their own specialized domain.	(Tiwana et al. 2005)
Coordination capability	The ability to manage interdependencies within a team	(Zhang et al. 2007)
Collective mind	A social system in which members heedfully interrelate their actions	(Yoo et al. 2001)

Table 2. Construct definition and source of items

Common Method Bias

Following Liang et al. (2007), we tested the impact of common method variance in the PLS model. There are 33 indicators and only 5 method factor loadings are significant. The ratio of substantive variance to method variance is approximately 30:1. Therefore, it might not be problematic in this study.

Reliability and Validity

Reliability is ensured because composite reliability, Cronbach's alpha and factor loading meet the minimum requirements. Convergent validity can be ensured based on item-to-total correlation (ITC), composite reliability, and average variance extracted (AVE) (Fornell et al. 1981). For discriminant validity, the correlations between construct pairs are lower than 0.90 and the square root of AVE are higher than the inter-construct correlation coefficients (Fornell et al. 1981). Detailed information is shown in Tables 3 and 4.

Construct	**Items**		**Loadings**	**ITC**
Project performance *Alpha=0.84* *CR=0.88* *AVE=0.55*	1	Ability to meet project goals.	0.76***	0.60
	2	Expected amount of work completed.	0.81***	0.72
	3	High quality of work completed.	0.80***	0.69
	4	Adherence to schedule.	0.71***	0.61
	5	Adherence to budget.	0.72***	0.60
	6	Expected benefits of work completed.	0.63***	0.46
Expertise complementarity *Alpha= 0.85* *CR=0.89* *AVE=0.63*	1	Each team member has specialized knowledge of some aspect of our project.	0.80***	0.64
	2	Members have knowledge about an aspect of the project that no other team member has.	0.78***	0.66
	3	Member of this team vary widely in their areas of expertise.	0.82***	0.72
	4	Members of this team have a variety of different backgrounds and experiences.	0.85***	0.74
	5	Members of this team have skills and abilities that complement each other’s.	0.72***	0.56
Transactive Memory *Alpha=0.75* *CR=0.86* *AVE=0.67*	1	The team has a good "map" of each others' talents and skills.	0.70***	0.43
	2	Team members know who on the team has specialized skills and knowledge that is relevant to their work.	0.86***	0.64
	3	Team members know which team members have expertise in specific areas.	0.89***	0.69
Task mental model *Alpha=0.80* *CR=0.88* *AVE=0.71*	1	Members can understand not only their own tasks but also others' tasks.	0.74***	0.60
	2	Members can make suggestion about others' task.	0.86***	0.73
	3	Members are specialists in their own part.	0.85***	0.62
Absorptive capacity *Alpha=0.81* *CR=0.89* *AVE=0.73*	1	Members have good capability to acquisition other’s knowledge and skills.	0.84***	0.62
	2	Members have good capability to assimilating other’s knowledge and skills.	0.87***	0.68
	3	Members have good capability to transform other’s knowledge and skills.	0.86***	0.69
Collective mind *Alpha=0.89* *CR=0.92* *AVE=0.75*	1	Our team members had a global perspective that includes each other’s decisions and the relationship among them.	0.83***	0.72
	2	Our team members carefully interrelated actions to each other in this project.	0.90***	0.84
	3	Our team members carefully made their decisions to maximize an overall team performance.	0.85***	0.71
	4	Our team members had developed a clear understanding of how each task function should be coordinated.	0.88***	0.75
Coordination capability *Alpha=0.71* *CR=0.82* *AVE=0.53*	1	Our team worked together in a well-coordinated fashion.	0.66***	0.51
	2	Our team had very few misunderstandings about what to do.	0.71***	0.45
	3	Our team needed to backtrack and start over a lot. (reversed)	0.74***	0.46
	4	We accomplished the task smoothly and efficiently.	0.80***	0.57
Market/Environment orientation *Alpha=0.82* *CR=0.87* *AVE=0.58*	1	Members frequently scan the relative situations (e.g. user, technology, organizational objective, or environment).	0.75***	0.61
	2	Members spend considerable time reading the relative data or information about the need and change of technique or environment.	0.71***	0.55
	3	Members quickly to discuss changes in the relative situations (user, technology, organizational objective, or environment).	0.82***	0.69
	4	Members devote a lot of time implementing ideas for the relative situations.	0.78***	0.63
	5	Members are quick to respond to significant changes in the relative situations (user, technology, organizational objective,	0.75***	0.56

		and environment).		

*NOTE: ITC: Item-total correlation; *** p<0.001*

Table 3. Reliability and validity

	Mean	Std	M3	M4	ACA	CMI	COO	MEO	EC	TM	PP	TMM
ACA	5.72	0.57	-1.28	2.62	**0.85**							
CMI	5.38	0.79	-0.91	1.05	0.44	**0.86**						
COO	5.80	0.57	-0.79	1.41	0.48	0.31	**0.73**					
MEO	5.74	0.51	-0.66	0.49	0.61	0.48	0.57	**0.76**				
EC	5.40	0.72	-1.46	3.24	0.63	0.34	0.43	0.46	**0.79**			
TM	5.73	0.59	-0.73	1.38	0.45	0.48	0.44	0.52	0.47	**0.82**		
PP	5.83	0.50	-0.65	0.51	0.58	0.46	0.47	0.66	0.60	0.51	**0.74**	
TMM	5.67	0.57	-0.77	0.99	0.39	0.49	0.36	0.54	0.40	0.41	0.56	**0.85**

NOTE:ACA: Absorptive capacity; CMI: Collective Mind; COO: Coordination capability; MEO: Market/Environment orientation; EC: Expertise complementarity; TM: Transactive Memory; PP: Project performance; TMM: Task mental model; Std: Standard deviation; M3: Skewness; M4: Kurtosis. The diagonal line of correlations matrix represents the square root of AVE.

Table 4. Descriptive analysis and correlation matrix.

DATA ANALYSIS

In this stage, PLS was used to test the proposed hypotheses. Test results are shown in Figure 2. First, dynamic capabilities have a strong positive impact on project performance. H1 is supported. Second, expertise complementarity, knowledge of the tasks of others and knowledge of the expertise of others (transactive memory) were found to have positive significant impacts on team dynamic capabilities. Among those three, the effect of expertise complementarity is the strongest, followed by knowledge of the expertise of others and knowledge of the tasks of others. Therefore, H2-H4 are supported. Lastly, the interaction between expertise complementarity and the task mental model is significant and negative while the interaction between expertise complementarity and knowledge of the expertise of others is significant and positive. Therefore, H5 is supported but H6 is not. In addition, these three factors and their interactions explain almost 60% if the variance of team dynamic capabilities.

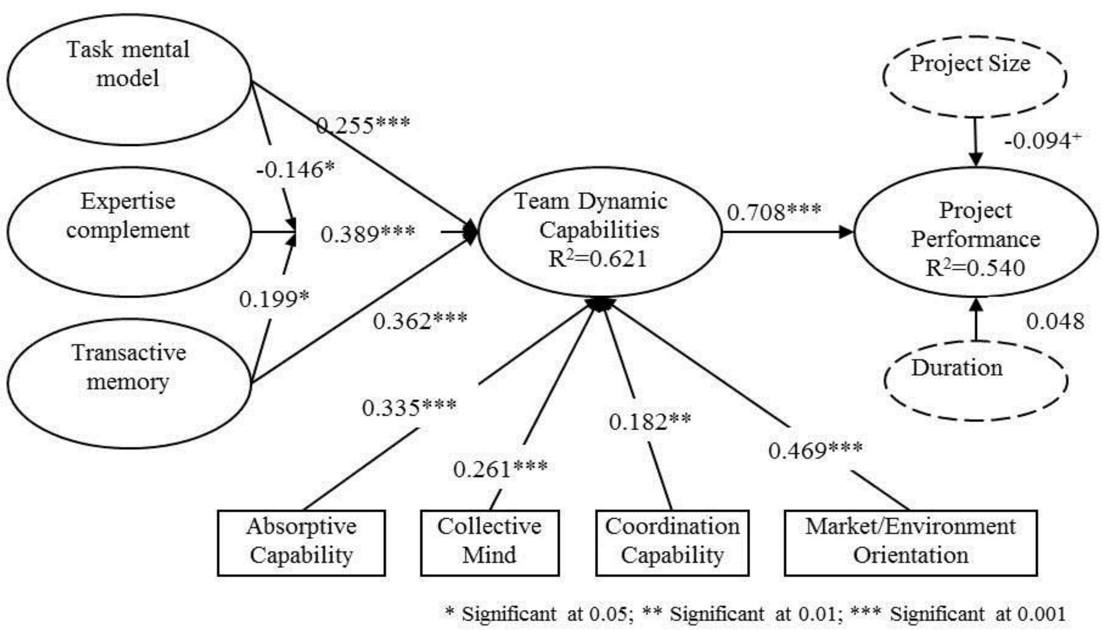

Figure 2. Path model

Discussion

Different from the original dynamic capabilities concept proposed by Pavlou and El Sawy (Pavlou et al. 2006), we used market/environment orientation to replace market orientation, while keeping the remaining three capabilities the same. We also found that the importance of each capability differed in our study and the previous study. In the previous study, in an NPD context, coordination and absorptive capacity are relatively more important (weigh more heavily) than market orientation and collective mind. However, in an ISD context, we found that market/environment orientation is strongest, absorptive capacity is next, collective mind is third, and coordination capability carries the least weight. Similar to the past study, absorptive capability plays a critical role, and the role of collective mind is relatively minor. However, coordination capability is more critical in the NPD context but less important in an ISD context. Lastly, the heaviest weight of the newly added dimension (market/environment orientation) indicates that being aware of changes in the external environment is very critical for an ISD project team.

Although both knowledge of the tasks of others and knowledge of the expertise of others are found to have strong moderating effects, these two variables generate different effects on the relationship between expertise complementarity and team dynamic capabilities. The positive coefficient of the interaction between expertise complementarity and knowledge of the expertise of others represents a complementary effect between these two variables. As shown in Figure 3, an increase in expertise complementarity can enhance team dynamic capabilities more when members know the expertise possessed by other members. In addition, a team with strong transactive memory (knowledge of the expertise of others) tends to have stronger team dynamic capabilities under different levels of expertise complementarity.

On the other hand, a negative coefficient of the interaction between heterogeneous expertise and task mental model was found. This result is totally different from our initial expectation. We hypothesized that these two were complementary and, therefore, a positive coefficient was expected. However, as shown in Figure 4, an increase in expertise complementarity has a stronger effect on team dynamic capabilities when knowledge of the tasks of others is low. Furthermore, if members know the tasks assigned to others, the team can have stronger dynamic capabilities even when the expertise possessed by its members is not complementary. This indicates that heterogeneous expertise and task mental model are substitutable. One of the most plausible explanations for this result is that each of them contributes to all parts of the team's dynamic capabilities. Although having heterogeneous expertise allows members to sense external changes and absorb external resources, knowledge of the tasks allows members to coordinate with each other and form a collective mind more easily. These factors are therefore substitutive since they generate effects on different parts of the team's dynamic capabilities.

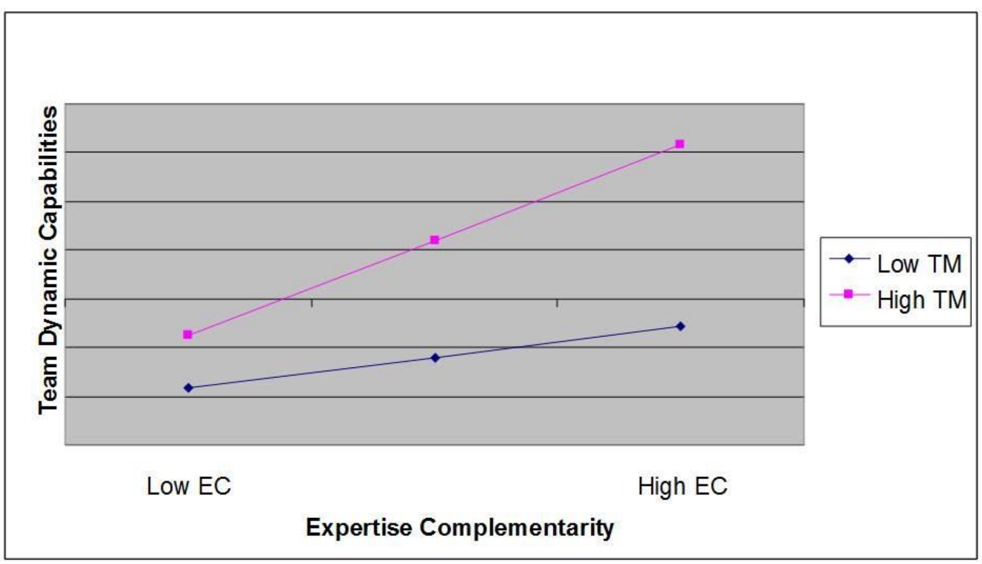

Figure 3. Moderating Effect of Transactive Memory (TM)

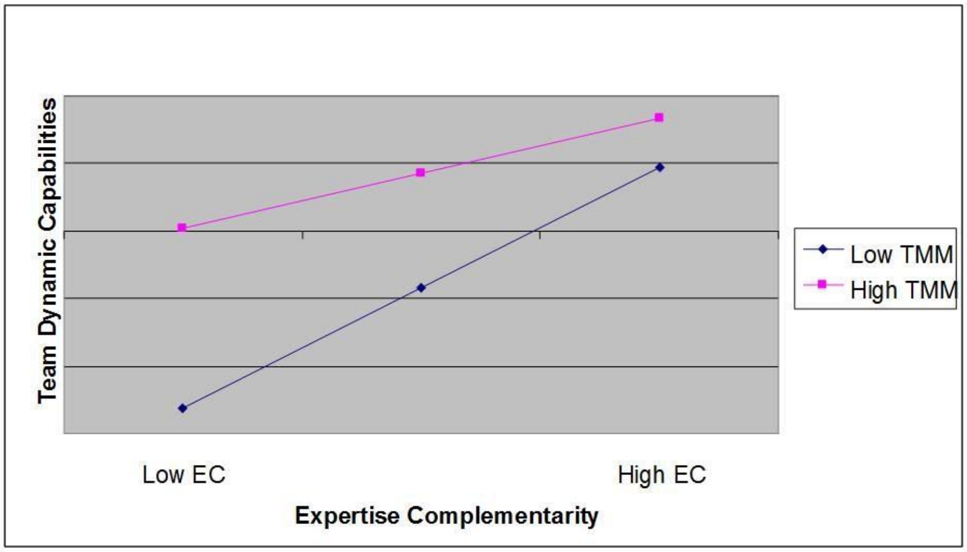

Figure 4. Moderating Effect of Task Mental Model (TMM)

CONCLUSION

The objectives of this study were to explore the importance of team dynamic capabilities on ISD project team performance and identify possible ways to enhance team dynamic capabilities. In addition, we also proposed that transactive memory, the task mental model and heterogeneous expertise can enhance team dynamic capabilities directly. Particularly, we further hypothesized the moderating effects of transactive memory and the task mental model on the relationship between heterogeneous expertise and team dynamic capabilities. Subjective data collected from 215 project managers and team leaders confirmed most of our hypotheses. Team dynamic capabilities are strongly correlated with team performance. In addition, heterogeneous expertise, transactive memory and the task mental model are all important in terms of building team dynamic capabilities. Lastly, transactive memory is complementary to expertise heterogeneity, and the task mental model is substitutable with expertise heterogeneity.

Limitations

Before further interpreting our results, several noticeable limitations of this study are worth noting. First, the sampling pool if this study is limited in Taiwan. Thus, the generalization of this study might be limited. Second, we validated our proposed model through cross-sectional data. It is also reasonable that having stronger capabilities may allow members to acquire more resources, and coordination among team members may allow them to be familiar with the expertise owned and tasks performed by others. However, the collected cross-sectional data does not allow us to answer this type of question. Therefore, future studies are encouraged to reexamine the proposed concept by using longitudinal data to clarify the above issues. Third, we collected data from only one member in each team. Opinions from a greater number of team members may be needed to provide a more precise result, especially regarding transactive memory and the task mental model. Finally, we explored the antecedents of team dynamic capabilities from an expertise perspective. We believe that other factors, such as teamwork mechanisms, have certain effects as well. And there might be other contingency factors that should be included but out of the boundary of our model for now. Future studies are encouraged to discover other antecedents of team dynamic capabilities and include more contingency factors. However, in spite of the above limitations, this study still contributes to academia and practitioners in the following ways.

Implications to Academia

First, in this study, we proposed the team dynamic concept and demonstrated its importance to ISD project performance. The strong and significant relationship between team dynamic capabilities and teamwork performance indicates how important it is for contemporary ISD project teams to be dynamic. Based on related literature, we also highlighted four dynamic capabilities for ISD project teams, including market/environment orientation, absorptive capacity, coordination capability, and collective mind.

Second, we highlighted the importance of having complementary knowledge for forming dynamic capabilities. Based on the expertise-intensive nature of ISD, having sufficient, diversified, and complementary expertise is important. In addition, we also found that the task mental model and transactive memory can benefit team performance by enhancing team dynamic capabilities. The task mental model and transactive memory have been shown to have positive impacts on team performance. In this study, we advanced this concept by showing that the task mental model and team mental model enhance project performance by enhancing team dynamic capabilities.

Third, we demonstrated the moderating effect of the task mental model and transactive memory on the effect of expertise complementarity on team dynamic capabilities. Specifically, we showed that transactive memory is complementary to expertise complementarity in terms of team dynamic capabilities. The complementary role of transactive memory indicates that expertise complementarity can generate more impact when members know the expertise possessed by their teammates. When both conditions are present, teams can have stronger dynamic capabilities. We also found that the task mental model is substitutable for expertise complementarity. Knowing the tasks performed by each member is critical when members in the same team do not have complementary expertise. Having a shared understanding of the tasks allows members to coordinate with each other and form a collective mind regarding the task. Therefore, the team can still have certain dynamic capabilities when members know the tasks assigned to them and others even when they have insufficiently complementary expertise.

Implications to Practitioners

This study highlights how important it is for project managers to ensure that project teams have sufficient dynamic capabilities. Specifically, members in a team should be able to sense changes internal or externally, absorb expertise from external resources when internally absent, coordinate with each other, and form a collective mind for action. We also highlight that managers should ensure that members in the same team possess heterogeneous and complementary expertise. Therefore, project managers should pay particular attention to member selection. In addition to having members with different and complementary expertise, there is a need to build a strong transactive memory. Teams can better utilize available resources to form capabilities when they know the location of expertise. Lastly, the substitutive effect of the task mental model suggests that while team members must know their own tasks, project managers should also pay particular attention to member orientation. When members know all the tasks and how those different tasks interrelate, the team can form dynamic capabilities even when members do not have complementary expertise.

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