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The Role ofSocial Capital and Shared Mental Model inVirtualR&D Teams

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Abstract: The working style of virtual R&D team is becoming more and more popular, so lots of researchers concern about the performance of virtual R&D teams. Shared mental model (SMM) is a concept in psychology which is defined as a common thinking style developed by similar experience and individual mental models. In this paper, we consider two types of SMM, which are task-related SMM and member-related SMM, and hope to investigatewhether SMM could influence the performance of R&D virtual teams and the antecedent relationship of SMM using social capital theory. The research results indicate that we could use social capital theory to explain the antecedents of task-related SMM and member-related SMM.Wealso find that task-related SMM and member-related SMM are both positively related to virtual R&Dteam performance. This researchemphasizes the importance of the notice on SMM in virtual team establishment, which should be paid more attentions.

Key words: shared mental model; social capital; team performance;virtual R&D team

1. INTRODUCTION

Team work is more cooperative and adaptive than individual work[1] and the working results are more effective[2]. Lots of enterprises and organizations use such team style to generate new ideas and products, which is called research and development (R&D) teams [3]. And because of the international fiancé environment and thinking about budget saving, virtual R&D teams appeared which are defined as team members do not work in the same place, even the same country [4]. Most of the members in virtual R&D teams are knowledge workers or high-level technicians who communicate with other by information technology support [5]. How to increase the performance of virtual R&D teams are becoming the crucial concern of all the scholars and the industry Furthermore, the researches of psychology indicate that the high sharing level among team which could induce high team work performance is because of the similar cognition style of such team [6]. One of the notions of team cognition is shared mental model (SMM) and we could use SMM to explain the mechanism of the teamwork behaviors in virtual R&D teams [7]. SMM is a psychological concept which means that each team member need have common expectations and understandings of the working processes, targets, and the roles of other team members [8]. The virtual R&D teams are such teams that consisting of knowledge works who complete their job by mental activities [9]. Therefore, we conducted an empirical study to analyze SMM invirtual R&D teams, and our first question is:what is the role of SMM in virtual R&D team.

Research has found that SMM is critical for team performance and has been applied to software development teams since team members with high-level SMM could have cross-functional integration of task object understanding and sharing of a common goal from the organizational view [10-12]. However, few empirical studies have investigated the antecedents of SMM. In this paper, we think SMM as a capital which is owned by ourselves and could influence our work. Therefore, our second research question is trying to analyze whether the social capital factors could promote the development of SMM in virtual R&D teams.

This paper is using SMM to examine virtual R&D team performance and trying to find the antecedent of SMM from the view of social capital. We adopt partial least squares (PLS) method to analyze the data from

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R&D enterprises. The rest of our paper is organized as follows. In Section 2, we review the prior literature and present our research model and hypotheses, followed by a discussion of the research methodologyin Section 3. We report the results in Section 4. Finally, we discuss andconclude the implications of our findings in Section 5.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1 SHARED MENTAL MODEL AND VIRTUAL R&D TEAM PERFORMANCE

Shared mental model means that team members could predict and understand what their teammates are going to do by the common interpretations of team processes, goals, and the capability of other team members [1]. But SMM does not request the team members which own the same experience and knowledge, but emphasize the coordination and integration of different knowledge of different areas from different individuals and the facing of joint goals [13]. Therefore, SMM is a cognitive word in team context which could be used to explain certain behaviors of human teams from the aspects of categories, cognitive maps, belief structures, schema, and scripts [8].

The formation of SMM in work teams are beneficial for the work outcome, such as understanding the mates' actions, communicating efficiently, expecting the working results accurately, especially when team members are not working in the same office[14]. So the research of the influence of shared mental models (SMMs) to virtual R&D team performance is important and significant. Yang et al. [8] do their investigation in software development industry in Korea, who find out that SMM could improve the team performance and team commitment, and SMM strengthen the influence of skills (A-skill and T-skill) to team effectiveness. And Kellermanns et al. [15] research the improvement of SMMs on decision quality from the perspective that it could help team members understand other's thoughts and reduce the likelihood of conflicts. Johnson and Lee [16] examine the relationship between SMMs and task performance in online learning environment. They find out the teams' SMMs and such relationship is changeable according to the time that the team members join in the learning activities, and the relationship is significant. Also in the research of team learning, Tjosvold et al. [17] indicate that the team-level variables such as SMMs could help the team members overcome barriers to learning from mistakes and extent the orientation of problem solving.

Based on above reviews, we could indicate that the research of SMM in team has potential value because it is an explanatory mechanism to analyze the behaviors of team members. And there is few research about the SMM and virtual R&D teams. And SMM is an integration conception which could be separated into two types: task-related SMM and member-related SMM[8]. Therefore, we suggest the following hypothesis regarding the relationship between SMMs and ISD team performance:

Hypothesis 1a (H1a): Task-related SMMis positively associated with virtual R&D team performance.

Hypothesis 1b (H1b): Member-related SMMis positively associated with virtual R&D team performance.

2.2 SOCIAL CAPITAL THEORY AND SMM

Social capital is defined as a series of social relationship resources and could be regarded as a cherish asset used by actors for action [18, 19]. People use such asset to accomplish their jobs by exchanging the resources [20]. High degree of social capital is beneficial for knowledge integration and the relationship between communication environment and it in digital enable teams [21], knowledge sharing in real or virtual teams [22, 23], enhancing the group's effectiveness [24], facilitating IT outsourcing success [25] and so on. Therefore, social capital theory is often used in the research of individuals' behaviors within a team or an organization [26]. The most popular measurements of social capital are proposed by Nahapiet and Ghoshal[27] which saying that there are three dimensions of social capital: structural, relational and cognitive aspects. Many scholars use this framework to investigate the relationship of organization to employees' behavior [28], moderate the impact of communication environment to knowledge integration [21], improve the decision of information technology

outsourcing [25], and so on.Structural social capital includes overall patterns of the connections between actors. Relational social capital describes the assets created and developed through the history of interaction that influence the social actors' behaviors [27]. This dimension includes the relationships of trust, norms, identification and obligation.Finally, the cognitive social capital refers to the resources shared by social actors and such resources could lead to similar thoughts, judgments and interpretations of job and task [27].

In fact, virtual R&D teams are consisted of team members who share and transfer information and knowledge between others. Therefore, the essence of virtual R&D teams are small social networks [20] and it is reasonable for us to choose social capital theory to illustrate antecedents of SMM in virtual R&Dteams.We make the following hypotheses regarding the relationships of social capital and SMM.

Hypothesis 2a (H2a): Structural capital is positively associated with team's task-related SMM.

Hypothesis 2b (H2b): Structural capital is positively associated with team's member-related SMM.

Hypothesis 3a (H3a): Relational capital is positively associated with team's task-related SMM.

Hypothesis 3b (H3b): Relational capital is positively associated with team's member-related SMM.

Hypothesis 4a (H4a): Cognitive capital is positively associated with team's task-related SMM.

Hypothesis 4b (H4b): Cognitive capital is positively associated with team's member-related SMM.

According to the hypotheses above, our research model is in figure 1:

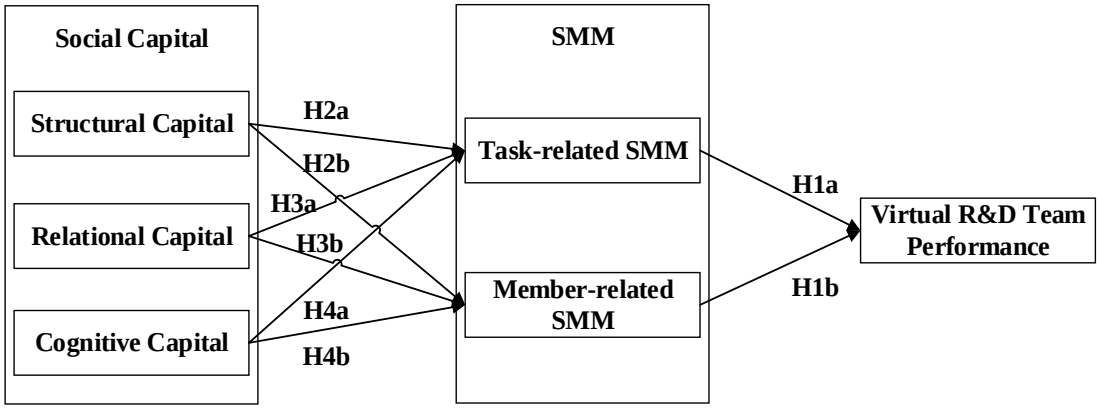

Figure 1. The detailed research model

3. RESEARCH METHODOLOGY

3.1 SAMPLE

Data were collected by surveys in Wuhan. Wuhan is the industrial kernel in the central China, so the conditions of Wuhan could represent the average level of China. At first, we choose 28 enterprises among the industries of information technology, information system and telecommunications.And these enterprises should have their own virtual R&D teams and should claim through the public media that they benefit from the virtual R&D teams.At first, we contacted with these 28 companies through email and telephone, by explaining our research and asking them whether to take part into these investigations. The agreements were received from 20 companies. We sent 500 questionnaires to these 20 companies by email and received 497 responses. After deleting questionnaires with missing answers, there were 461 surveys from 106virtual R&D teams in those 20 companies.The demographic characteristics of our sample are shown in Table 1.

Table 1. Sample DescriptiveStatistics

Variables	Categories	Count	%
Gender	Male	260	56.4%
	Female	201	43.6%
Education	Associate's degree	47	10.2%
	Bachelor's degree	216	46.9%
	Master's or higher	198	42.9%
Age	≤25 years old	32	6.9%
	25~30 years old	154	33.4%
	31~40 years old	198	42.9%
	＞40 years old	77	16.8%
Years of virtual team work experience	≤1 year	78	16.9%
	2~3 years	149	32.3%
	3~5 years	162	35.1%
	5~10 years	52	11.3%
	>10 years	20	4.4%

3.2 INSTRUMENT DEVELOPMENt

We developed the scales based on the extant literature whenever possible to ensure the contentvalidity and usedseven-point Likert scales, whose anchors ranged from one (strongly disagree) to seven (strongly agree), to measure the constructs.

We used the constructs of Chiu et al. [4] to measure the structural social capital(RSC) and adapted the items of cognitive social capital (CSC) and relational social capital (RSC) from van den Hooff and Huysman[28]. Task-related SMM (T-SMM) and member-related SMM (M-SMM) were measured by the constructs from Yang et al. [8].At last, we used the items from Wakefield and Leidner[29] to value the virtual R&D team performance. The virtual R&D team performance (VTP) was measured at team level, and other variables were measured at individual level. So we should aggregate these variables from individual level to team level.

4. RESEARCH RESULTS

4.1 ANALYSIS OF RELIABILITY AND VALIDITY

We use structural equation modeling to test our hypotheses and choose Smart PLS (Partial Least Squares) because it is useful when we investigate the exploratory studies [30] and our data number 106 (at the team level) is a little bit small for other SEM tools using covariance-based analysis, such as Liseral and Amos.

Expect team performance, all the other factors were measured at the individual level. Because our research is conducted at team level, team-level measure needs to be aggregated from individual team member responses at first. We used the parameter of r_{wg} to measure the 'goodness' of data aggregation. All the 106 teams' value of

r_{wg} are above 0.7, which indicated that we could use the individual-level data aggregation to represent the teams' characteristics [29].

We conducted a confirmatory factor analysis (CFA) to test the measurement model for the scales' reliability and validity (Table 2).As shown in Table 2, all of the Cronbach's alphas and CRs were over 0.7, which indicated that the scales had satisfactory reliability[31]. The average variancesextracted (AVE) for all constructswere all above 0.5, which meant that the scales had good convergent validity[31].

Table 2. Measurement Model Testing Results

Factor	AVE	CR	Cronbach'sAlpha
SSC	0.686	0.891	0.869
CSC	0.794	0.920	0.865
RSC	0.666	0.866	0.807
T-SMM	0.631	0.871	0.802
M-SMM	0.623	0.868	0.797
VTP	0.689	0.917	0.887

We then tested the discriminant validity by comparing the square root of each factor's AVE with its correlation coefficients with other factors [32]. From Table 3, we can see that all square roots of AVEs were larger than their corresponding correlation coefficients with other factors. Thus, our data had good discriminant validity.

Table 3. Correlation Matrix and Square Roots of AVEs

	SSC	CSC	RSC	T-SMM	M-SMM	VTP
SSC	0.828					
CSC	0.414	0.891				
RSC	0.521	0.571	0.816			
T-SMM	0.548	0.396	0.483	0.794		
M-SMM	0.395	0.308	0.382	0.553	0.789	
VTP	0.516	0.409	0.580	0.419	0.378	0.830

To avoid common method bias, we disordered the ranking of our questionnaires and reversed some questions. We used exploratory factor analysis of items and checked if any single construct owning significant variance across all items [8]. The results show that all the six constructs'eigen values are above one, and no construct's explained variance is too big, which means that no construct is the main factor in the structure.

4.2 HYPOTHESIS TESTING RESULTS

Figure 2 represents the hypothesis testing results for the full model which contains the relationships among three dimensions of social capital and the impacts of SMM and virtual R&D team performance. All the nine hypotheses are significant and supported. The three dimensions of social capital explain 24.8% of the change of task-related SMM and 19.5% of the change of member-related SMM in virtual R&D teams. Andbothtask-related SMM and member-related SMMexplain 19.5% of the change the virtual R&D team performance.

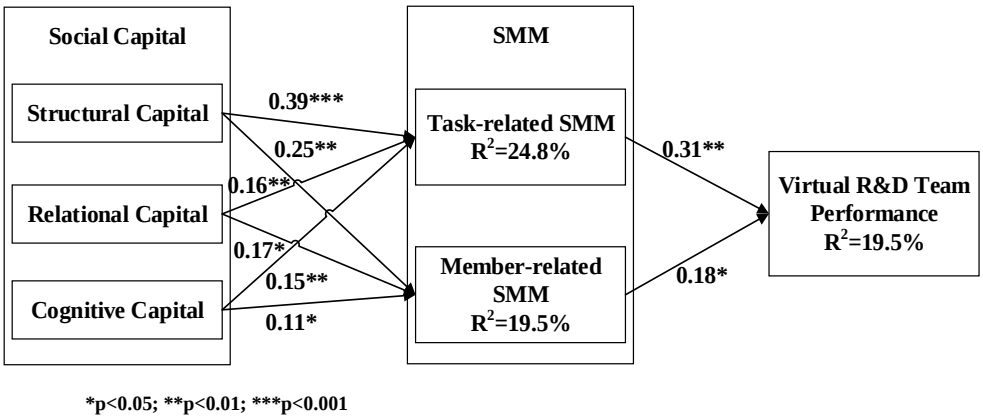

Figure 2. Full model test result

5. DISCUSSION

From the research results above, all the hypotheses are proved by structural equation model software Smart PLS, which indicate that SMM is significant in virtual R&D teams and using social capital to explain the antecedents of SMM is reasonable.

Hypotheses 1a and 1bshow the direct relationships between SMM, and virtual R&D team performance. If teams formulate high degree of both task-related SMM and member-related SMM, they could have the capabilities and consciousness to share their experience and opinions with their colleagues. They could willing to help their colleagues when they meet troubles, and such good intentions could also exchange for the respect and help from others. This is fatal to the survival and development of enterprises. The significance of H2a, H2b, H3a, H3b, H4a and H4b indicate that the three dimensions of social capital, which are structural capital, relational capital and cognitive capital respectively, could influence the degree of task-related SMM and member-related SMM positively. Structural social capital emphasizes the interactions and structural ties among team members. And in virtual R&D teams, members could not usually use the general communication methods such as face-to-face talk and regular meeting.Therefore, they should exchange information and knowldege through the assistance of digital tools and networks.The impact of the relational social capital on task-related SMM and member-related SMM, which includes the emotional factors between individuals such as trust and identification, is also significant. In today's knowledge works, the competitions are fierce. Merely the existence of communication tools and channels is not enough for virtual R&D team members forming SMMs. In this circumstance, trust among them is especially fatal of virtual team work. Only when one person feels that his/her payout could gain payback and respect, he/she may have the friendly attitude toward others, share the experiences and then constitute the SMMs with others. Cognitive social capital represents team members sharing the same goals, tools and working process, which is positively related to SMM by our test. These sharing things are the basis of the SMM establishment, and SMM are only formatting when members treat the similar tasks and use the similar languages during the similar phase of the work.

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