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The Antecedents and Consequences of Agile Practices: A Multi-Period Empirical Study of Software Teams in Time-Bound Projects

Xiao Tang
University at Buffalo

Rajiv Kishore
University at Buffalo

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Xiao Tang
326 Jacobs Management Center
University at Buffalo
The State University of New York
Buffalo, New York 14260-4000, USA.
Tel: (716) 645-5255; FAX: (716) 645-6117
e-mail: xiaotang@buffalo.edu

Rajiv Kishore
325N Jacobs Management Center
University at Buffalo
The State University of New York
Buffalo, New York 14260-4000, USA.
Tel: (716) 645- 3507; FAX: (716) 645-6117
E-mail: rkishore@buffalo.edu

ABSTRACT

Through a multi-period study of software teams in time-bound projects, we address the question: In what contexts do agile methods improve systems development performance? Our model includes team network and task characteristics as antecedents and transactive memory system (TMS) as a consequence of the use of agile practices. We further posit that team TMS also moderates the impact of agile practices on project performance. We test the hypothesized model using data collected in three waves from student teams who developed a database system over the course of a semester. Results evince that project performance does not improve through the use of agile practices alone, but does improve when task variability is high and the project team has a high degree of TMS. Results also indicate that the knowledge structure of a software team changes over time and the use of agile practices also directly contributes to the development of TMS within the team.

Keywords

Agile project management, agile practices, team knowledge network, task variability, transactive memory, project performance.

INTRODUCTION

The term 'software crisis' was first coined at the NATO Software Engineering Conference in 1968; at that point, the information systems (IS) development arena was in a poor state, with severe backlogs and a high number of canceled, failed, or delayed IS development (ISD) projects. Software crisis persists despite more than four decades of progress in the ISD field and the advent and diffusion of ISD tools, technologies, and methodologies. Standish Group's Chaos (http://www.standishgroup.com/) reports are based on an analysis of data on more than 40,000 software projects and are widely recognized in the field as an authoritative report card on the state of affairs in ISD; recent Chaos reports indicate that IS project success rate was still a dismal 32% in 2009 with canceled projects costing over $55 billion that year.

Prominent software practitioners formally introduced the terms "agile systems development" and "agile project management" sometime in the mid-1990s and subsequently signed a Manifesto for Agile Systems Development. Agile approaches for systems development and project management were essentially a response to the continuing crisis in the systems development arena. Since then this area has gained increasing attention of both practitioners and academics, although most research and publications are still practitioner-driven and practitioner-oriented (Baskerville, Mathiassen, Pries-Heje, and DeGross, 2005; Conboy, 2009; Highsmith, 2004a; Highsmith, 2004b). Generally, agility in a business context is the ability to create and deal with changes in order to profit in a competitive business landscape (Conboy, 2009; Highsmith, 2004a; Highsmith, 2004b; Sarker et al., 2009). In ISD context, agility is the ability of "information systems development and deployment methods to swiftly adapt to the changing business requirements" (Lee, Banerjee, Lim, Kumar, van Hillegersberg, and Wei, 2006). Although proponents of agility in ISD highlight advantages of these approaches and provide concrete project development and management methods for software development projects (e.g., Highsmith, 2004a; Highsmith, 2004b; Holmström, Fitzgerald, Ågerfalk, and Conchúir, 2006), these methods and approaches are not free of criticism. Critics argue that agile methods are "light-weight" and cannot be applied in all contexts and all projects. Perhaps as a result, diffusion of agile methods has been relatively slow since the first formal extreme programming project in 1996 (Conboy, 2009).

Agile methods may be inherently "weak" and the weak diffusion of these methods explained by systems developers and managers correctly identifying those weaknesses. Mixed results from the use of agile methods may be due to their misapplication to wrong projects and in the wrong contexts, however. Other academic studies are also beginning to examine other aspects of this methodology (e.g., Conboy, 2009; Sarker et al., 2009; van Oosterhout, Waarts, and van Hillegersberg, 2006; Vinekar, Slinkman, and Nerur, 2006), but much remains to be studied. We extend this body of literature and ask two specific research questions: 1) What are the important antecedents that predict agile methods use in systems development? and 2) In what contexts do agile methods improve systems development project performance? Through a multi-period study of software teams in time-bound projects to address the above research question, we make three key theoretical contributions to the literature. First, we show that the use of agile practices does not improve project performance just by itself but does so when project task variability is high and the software team has a high degree of transactive memory system (TMS). Second, we show that the knowledge structure of software team changes over time, with team density increasing or reducing over time depending upon the initial knowledge structure of the software team. Finally, we show that the use of agile practices also directly contributes to the development of TMS within the team.

The rest of the paper is organized as follows. We begin our discussion with theoretical foundations and the research model and hypotheses. This is followed by research methods used. We then discuss the results and their implications.

THEORY

Theoretical Foundations

Team-Based Work Literature

Because software development, and particularly agile software development, occurs predominantly in teams, team-based work literature from the organizational behavior (OB) and IS areas are most relevant to this study. The Input-Process-Output (IPO) model is a foundational theoretical model used in team research in the OB arena (Ilgen, Hollenbeck, Johnson, and Jundt, 2005; Jarboe, 1988; Stewart et al., 2000). The notions in the IPO model are very similar to the ones used in the systems arena. In the team-based work context, inputs could include team and task characteristics, environmental contexts, and other contingencies; process consists of team dynamics, other team processes such as transactive memory, etc.; and various aspects and measures of team performance indicate output.

Many previous team-based work studies various group characteristics as antecedents to project performance. Campion et al. (1993; 1996) studied the relationship between various work group characteristics (including job design, interdependency, composition, context, and process) and team effectiveness. Team and project performance are also affected by the degree of expertise and objective task complexity (Haerem et al., 2007) and conflict (Jehn et al., 2001). Group interactions have also been found to affect group level performance (Hackman et al., 1975; Jehn et al., 2001). Some recent research studies of team interactions have argued that the Input-Process-Output model is not necessarily linear and have proposed other path variants including moderation effects.

Information System Development Literature

More recently, agile development and project management methods have been proposed, primarily by the practitioner community, due to the failure of traditional project management approaches in systems development. In 2001, representatives of various agile methods including Extreme Programming, Scrum, the Dynamic Systems Development Method, Adaptive Software Development, Crystal Methods, Feature-Driven Development, Pragmatic Programming, and others produced *The Manifesto for Agile Software Development* (http://agilemanifesto.org/) that formally highlighted four principles: 1) individuals and interactions over processes and tools; 2) working software over comprehensive documentation; 3) customer collaboration over contract negotiation; and 4) responding to change over following a plan.

Synthesizing previous efforts, Conboy (2009) defined information systems design agility as "the continual readiness of an ISD method to rapidly or inherently create change, proactively or reactively embrace change, and learn from change while contributing to perceived customer value (economy, quality, and simplicity), through its collective components and relationships with its environment." Conboy (2009) also identified several problems concerning the principles of agility including lack of concept clarity, lack of "theoretical glue," lack of understanding about applicability in a variety of ISD contexts, etc. Research efforts have only recently begun to address these concerns systematically, including the clarification and verification of the theoretical boundaries of agile methods. For example, Maruping, Venkatesh, and Agarwal's study (2009) draws upon control theory to identify the conditions under which agile principles and practices are most effective in improving software project quality. The above discussed theoretical underpinnings form the basis of our development of the conceptual research model for this study.

Conceptual Research Model

We developed our conceptual research model by synthesizing the IPO model from the team-based work literature and the systems development literature, discussed above. Following the team-based work literature, we also conceptualize our research model as a multi-period model with three time points in the software development team process – early phase, middle phase, and late phase. The IPO model used in the context of team-based work research is particularly suited to this study because of the focus in agile methods on interactions among individuals working in teams, as reflected in the agile manifesto (http://agilemanifesto.org/). The fundamental question of the appropriateness of agile methods for various ISD projects is essentially a question of which project task characteristics (Haerem et al., 2007) make agile methods more suitable than others. Further, the focus of agile methods on interactions among team members points to the need for capturing the network structure (Balkundi et al., 2006; Tushman et al., 1980) with reference to the knowledge-related interactions among team members. As a result, these two constructs were chosen as two key input variables in our research model. Agile practices (Holmström et al., 2006; Meso et al., 2006) themselves are the key process variable in our IP model. In addition, we include an important process construct called transactive memory system (TMS) in our model, as recent research has highlighted the importance of TMS in knowledge work in general (e.g., Austin, 2003; Lewis et al., 2005), and in software development work in particular (Faraj et al., 2000). Finally, from an output perspective, we include project performance (Hoegl et al., 2001) in our model as it captures performance at the project level. Figure 1 demonstrates the final research model and captures all the other relevant hypothesized paths.

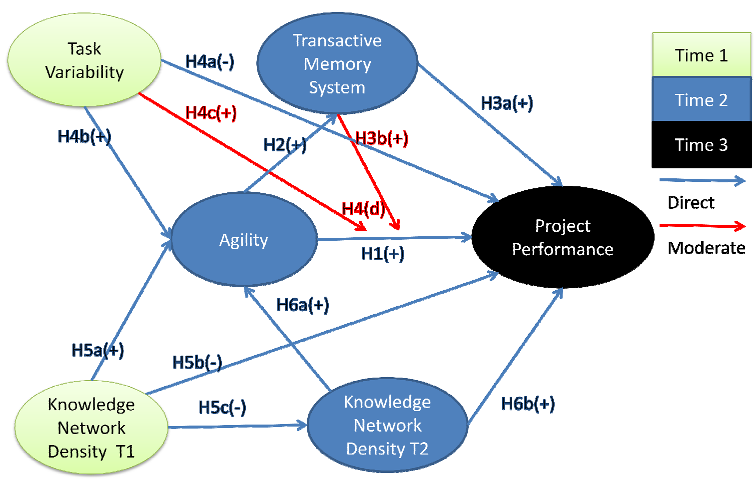

Figure 1: Conceptual Research Model

Theory and Hypothesis

Agility in Software Development Projects

Agile project development targets software products and internally developed business IT system products (Highsmith, 2004a). The fundamental premise and goal of the Agile Manifesto is to adapt to changing business requirements swiftly, using the four principles or practices of agility, including team interactions, customer collaboration, working software, and responding to change (http://agilemanifesto.org/). Highsmith (2004a) stresses the importance of working product, customer collaboration, team interactions, and responsiveness to change for achieving high software product quality and high process efficiency. Team interactions and customer collaborations, as well as development and delivery of working software in smaller time boxes, will increase the likelihood of getting the "true" business requirements right and improving project performance. Further practices that enable responding to changes quickly will also ensure that a wrong understanding about business requirements is not reified in the final software products. Recent empirical studies also found that use of extreme programming, a type of agile method, increases software quality (Maruping et al., 2009). Therefore, we hypothesize:

H1. Use of agile practices will positively influence software project performance.

Transactive Memory System

TMS is understood as a memory system to create, transfer, store and retrieve knowledge in group level, which takes time to develop TMS over group communication, monitor and trust (Lewis et al., 2005). Lewis (2003) gives three measurement dimensions of TMS: specialization, credibility, and coordination. Project performance is a team work outcome of group performance in context depending on resource application and individual learning and collaboration (Campion, Medsker, and Higgs, 1993). No matter the pattern of knowledge creation, social connections within groups and knowledge mapping are essential components (Alavi et al., 2001; Nonaka, 1994). Agility principle focuses on unique talent and skills, which improves development individual's specialization without doubts (Highsmith, 2004a). At group level, innovation and clarity help knowledge collaboration from new idea and they also assist knowledge mapping of job assignment and obligation (Alavi et al., 2001; Nonaka, 1994), therefore, we propose the following hypotheses:

H2. Use of agile practices will positively influence transactive memory system.

Previous studies demonstrate that groups with TMS create more knowledge sharing and perform better than the groups without TMS (e.g., Liang, Moreland, and Argote, 1995; Moreland et al., 2000). TMS is involved in explaining team performance in terms of members' knowledge management and learning processes (Lewis, 2003). Teams with effective TMS exhibit three dimensions of behavioral abilities – recognize, trust, and coordinate specialized knowledge (Kanawattanachai et al., 2007) and such dimensions have a positive impact on team creativity (Amabile, Conti, Coon, Lazenby, and Herron, 1996) and then project performance. This leads to the next hypothesis:

H3a. Transactive memory system will positively influence software project performance.

TMS not only directly boosts project performance; it also moderates agility effects on performance. Effective knowledge transfer will enhance the project creativity in agility-stimulated project (Perry-Smith, 2006; Perry-Smith et al., 2003). Since TMS embraces the knowledge deeply implanted in a project, TMS' perspectives will positively influence effective knowledge transfer. Griffith, Sawyer, & Neale (2003) posit that the transferring process of potential knowledge to usable one is positively moderated by transactive memory. The foregoing logic leads to the following hypothesis.

H3b. Transactive memory system will positively moderate the impact of the use of agile practices on software project performance.

Task Variability

Task variability is defined as the number of exceptional situations (or unfamiliar stimuli) encountered during a task completion (Perrow, 1967). Variability or uncertainty exists in market payoff, budget, market requirement, project schedule, and product performance (Katz et al., 1979). High risk lies in purely uncertain and variance situations and endangers performances. And we propose this hypothesis:

H4a. Task variability will negatively influence software project performance.

Uncertainty or risk resides in proposed project outcome and proposes the needs to fit the properties of product by reducing the uncertainty and mitigating risk over project life (Highsmith, 2004a). Agility is an attitude to environments rather than methodology emphasizing quick and dynamic adaptation to new circumstances so as to combine strength and nimbleness which creativity is survival condition in competitive business world (Highsmith, 2004a). Creativity is a survival condition in the competitive business world, and without it, there is not enough knowledge to quickly generate a customer-focused product. Hence, we propose the following hypothesis:

H4b. Task variability will positively influence the use of agile practices.

Task variable sets up the integrant needs for flexibility and adaptation in project operations. When unexpected factors surprise project operating, individuals prepare for actions or tasks by interpreting and redefining their tasks according to their knowledge and abilities(Hacker, 2003; Jones et al., 2008). To some extent, TMS is a type of social network that describe group map in knowledge sharing and learning to facilitate action then improves agile adaptation (Perry-Smith, 2006). Knowledge transfer is faster and adaptive capability is more effective and efficient with a combination of clear needs for flexibility from the task's nature, strong cooperation and fast response ability to exploit transactive memory. Therefore, we propose such hypothesis:

H4c. Task variability will positively moderate the impact of the use of agile practices on software project performance.

H4d.Together task variability and transactive memory system will moderate positively the impact of the use of agile practices on software project performance.

Social Networks

Maslow's hierarchy of needs posits that humans want to feel a part of social networks, no matter big or small. A social network represents social relationship or non-connection between entities in groups. Network density offers a measure for interaction proposition, whereby the original knowledge network enhances basic communication and solidify the future cooperation, for example climate, routine or operating procedure (Balkundi et al., 2006; Brass, Galaskiewicz, Greve, and Tsai, 2004). Hence work-related knowledge sharing is more easily and fluently accomplished in a dense network. Early knowledge network captures the rough picture of group norm and climate (Bock, Zmud, Kim, and Lee, 2005), and also helps individuals gradually fit in groups for belongs (Giddens, 1984; Jones et al., 2008). With a dense initial knowledge network, sharing and creativity in an agility project bloom in the midterm stage. We thus propose the following hypothesis:

H5a. The density of the initial knowledge network will positively influence the use of agile practices.

Group norm and routine resist the principle of personality in agile practice. The early understanding of group norms easily polishes and therefore gradually diminishes individual personality and flexibility since individuals in groups intend to fit in and belong, and so they monitor others' activities, then modify their own behaviors through flexible communications and quick responses (Giddens, 1984). Creativity and flexibility in agility projects grow fainter with strong norms and routine cognation, thereby jeopardizing final project performance. We propose the hypothesis below:

H5b. The density of the initial knowledge network will negatively influence software project performance.

Networks are not static but dynamic structures, and network process is constructed as the series of events that create, sustain and dissolve social structure (Doreian et al.,1997) . Group members in position of structure hole gain power and control as resource broker. Access to novel and diverse knowledge might results in better performance, but good performance requires expensive cost such as time and attention to maintain the short-living strategic advantage (Burt, 1992) because all advantages dilute and fade as time passes (Soda, Usai, and Zaheer, 2004). Besides, early stage familiarity and knowledge sharing lower the requirement of the future communication (Gido et al., 1998). Therefore, we propose the following hypothesis:

H5c.The density of the initial knowledge network will negatively influence the density of the midterm knowledge network.

When agility project proceed from preparation to deeper execution, product over process requires more adjustment of project target, and communication is essential to create such flexibility and individual creativity (Perry-Smith, 2006). In mid-term stage, knowledge network plays live-or-die roles in project survival. Socialization in network influence both individual and group level of knowledge management effectiveness including creation, transfer and storage (Nonaka, 1994). Since communication supports knowledge creativity and sharing activities, mid-term knowledge network exponentially enrich potential capability and ultimately promote project performance. All communication in midterm phrase increases agile project performance. Therefore, we propose this hypothesis:

H6a.The density of the midterm knowledge network will positively influence the use of agile practices.

H6b.The density of the midterm knowledge network will positively influence software project performance

RESEARCH METHOD

Sample

The study sample is online survey of undergraduate students in a database course. Teams' project performances were highly similar and their life cycles were identical according to course syllabus, thus ruling out mitigating factors. Teams work to development a database system for a company in which one group member has been working or worked above 6 months. And teams gather in labs once a week for a designated time during which team members can work closely with each other over a four-month period with significant deliverables (a class presentation and a project report to teaching assistants). Thus, in survey questions, all client-related questions are changed into teaching assistant or course instructor.

Data from teams were collected through three waves of surveys: the first wave is at the beginning of the course, the second wave is in the middle of the course and the last one is one week before final deliverables were completed. To validate individual data, groups with more than 50% valid responds are kept. Finally reliable data set is 98 teams comprised of undergraduate students (total number = 388) and a 57.6% response rate. Team size is from 3 to 5 and ages range from 19 to 42. And in model building, gender and ethinicity is transferred into group Blau's index and age is presented by age coefficient. Table 1 display descriptive statistics.

	N	Minimum	Maximum	Mean	Std. Deviation
Group Size	98	3.00	5.00	3.949	.73740
Gender Diversity	98	.00	.50	.3300	.18941
Age Coefficient	98	.00	.44	.0912	.09195
Ethic Diversity	98	.00	.67	.3290	.22580

Table 1 Sample Descriptive Statistics

Measurement

One of contributions is our items development of Agility on four dimensions: Individual and Interaction (TC), Working Software (WS), Customer Collaboration (CC) Responding to Change (RC). Following five-point scale, 1 represents "strongly disagree" and 5 means "strongly agree". Using the five-item measure developed by Lewis (Lewis 2003), TMS is rated on five-point scale and task characteristics adopt Haerem (Haerem et al., 2007)'s measurement. Project performance is measured by Hoegl (Hoegl et al. 2001)'s survey questions and team knowledge network is measured at wave one (KNT1) and two (KNT2), and the detail survey question is to list the name that "I regularly get project-related advice from…" ,then we apply UCInet to get each group density as model boundary variable. Accounting for the heterogeneity of the sample, we controlled for team ethnicity, class, age, gender, and team size. All detailed survey questions are listed in Table 2. Since it is a newly-developed measurement, in the following CFA model, we set critical value of loading to 0.4 as Lewis's formative tests (Lewis, 2003). The measurement items, loadings, and dimension Cronbach's Alpha are list in Table 2.

Construct	Item	Loading	Cronbach's Alpha
Customer Collaboration (CC)	Group members shared their opinions with the instructor/teaching assistants.	0.86	0.802
	Group members shared task-related information with the instructor/teaching assistants.	0.8	
	Group members regularly discussed the project requirements and progress with the	0.68	

	instructor/teaching assistants		
Team Collaboration (TC)	Group members collaborated with each other.	0.71	0.842
	Every group member was involved in each working process.	0.66	
	Group members met with each other frequently for the task.	0.82	
	Group members interacted with each other quite a lot on this project.	0.86	
Working Software (WS)	Each iteration of our system had a clear goal.	0.74	0.681
	Our velocity in developing a working system was quite high.	0.58	
Adaptive Response (AR)	Work procedures were modified in response to changes rather than following a plan.	0.7	0.618
	Our group changed the project plan often as we continued to learn and make progress on the project.	0.47	
Specialization (SPE)	Each team member has specialized knowledge of some aspect of our project	0.7	0.638
	I have knowledge about an aspect of the project that no other team member has	0.52	
	The specialized knowledge of several different team members was needed to complete the project deliverables.	0.59	
	I know which team members have expertise in specific areas.	0.62	
Credibility (CRE)	I was comfortable accepting procedural suggestions from other team members.	0.69	0.799
	I trusted that other members' knowledge about the project was credible.	0.84	
	I was confident relying on the information than other team members brought to the discussion.	0.73	
	I did not have much faith in other members' "expertise".	0.47	
Coordination (COO)	Our team worked together worked together in a well-coordinated fashion.	0.77	0.682
	Our team had very few misunderstanding about what to do.	0.61	
	Our team needed to backtrack and start over a lot.	0.46	
	We accomplished the task smoothly and efficiently.	0.73	
Task Variability (VA)	To what extent did you come up againist unexpected factors in responding to the above requirements?	0.57	0.869
	To what extent do you feel that your solutions were vague and difficult to anticipate?	0.7	
	To what extent do you feel that it is difficult to identify a solution to the requirements?	0.8	
Project	Going by the results, this project can be	0.69	0.807

Performance (PP)	regarded as successful.		
	The project result was of high quality.	0.79	
	The team was satisfied with the project result.	0.76	

Table 2 Survey Items of Agility, TMS, Task Variability, and Project Performance

Results

Validity of Multilevel Data Structure

These research analyses are held on team-level constructs out of individual-level data. Two different analyses should be performed to validate this data structure. First, we examined whether the data empirically justified aggregation of team-level implication. According to basic ANOVA test, team learning behavior significantly differed between teams. The other test is inter-rater agreement with indicators of intra-class correlation coefficients (ICC1, ICC2) and RWG(J) (James, Demaree, and Wolf, 1984) and the range and mean of ICC2 for agility and TMS items correspondingly are 0.99 (ranging from 0.69 to 1.31) and 0.98 (ranging from 0.70 to 1.18). The average RWG(J) of agility and TMS across groups are 0.78 and 0.88. ICC2 and RWG(J) with a size of .70 or higher are desirable (Klein, Bliese, Kozlowski, Dansereau, Gavin, Griffin, Hofmann, James, Yammarino, and Bligh, 2000). These results showed that individual collected data is qualified to aggregate and represent group level information. Therefore, in the following modeling process, all group level data are obtained by the average of individual data.

Multilevel factor analysis is another important test to provide a more comprehensive understanding of a multilevel data structure. Confirmatory factor analysis (CFA) is tested on the constructs of agility, TMS and project performance. A unidimensional first-order factor accounts for the variance among all measurement items of each variable in Test 1, and Test 2 takes all items into several freely correlated first order structure. Significant improvement can be seen in Table 3 comparing the two tests in each measurement. The result shows high reliability in first order model of agility, TSM and total model with agility, TMS, task variability and project performance (Tanriverdi, 2006).

Variable	Model	Chi^2 / DF	GFI	CFI	NFI	RMSEA
Agility	**Test 1**	427.2/44	0.832	0.776	0.758	0.146
	Test 2	110.6/38	0.953	0.958	0.937	0.069
TMS	**Test 1**	309.5/54	0.873	0.836	0.809	0.108
	Test 2	172.3/51	0.934	0.922	0.894	0.077
Total Model	**Test 1**	4793.5/464	0.506	0.53	0.506	0.152
	Test 2	919.5/341	0.869	0.881	0.826	0.065

Table 3 Agility, Transactive Memory Systems and total model: CFA models' Reliability Measures and Goodness of Fit Statistics

After aggregating all individual item score into group data, we upgrade the research level to group empirical study. Also similar to Maruping's (Maruping et al., 2009) study, TMS structure levels up to first order structure, which contains three indicators (specialization, credibility and coordination) out of an average score of each original dimension. Similarly, agility is represented in one indicator by total average score with all items.

Discriminant validity is estimated through: (i) cross-loadings, and (ii) correlations among latent constructs and the square roots of AVE. Table 4 provides a list of standardized loadings for each construct, and it is seen that they are above the acceptable minimum requirement in the highlighted zones. The relationship between square roots of the AVE values and the correlations among latent constructs support the same conclusion. In Table 5, the square roots of AVE (diagonal values) are greater than the correlations among the constructs (off-diagonal values).

	TMS	PP	VA
COO_mean	0.804	0.0659	-0.2097
CRE_mean	0.8722	-0.1347	0.0246
SPE_mean	0.7961	0.0496	-0.0853

PP1	-0.0941	0.8713	-0.1862
PP2	-0.0314	0.9088	-0.2921
PP3	0.0903	0.8895	-0.1752
VA1	-0.0323	-0.1387	0.7922
VA2	-0.0478	-0.1895	0.825
VA3	-0.139	-0.2738	0.9161

Table 4 Crossloading of Items and Variables

	N	Mean	Std Deviation	Size	Gender	Age	Ethic	AN_T1	KN_T2	VA	CC	TC	WS	AR	SPE	CRE	COO	PP
Size	98	3.949	0.73740208	1														
Gender	98	0.33	0.18940772	-.076	1													
Age	98	0.091	0.09194607	-.083	-.093	1												
Ethic	98	0.329	0.22579892	-.085	.107	.193	1											
AN_T1	98	0.145	0.1860006	-.100	-.147	-.055	-.345**	1										
KN_T2	98	0.329	0.20154372	.199*	.098	-.236*	.009	-.190	1									
VA	98	2.861	0.30087349	-.153	-.140	-.006	-.091	.163	-.066	0.651								
CC	98	3.517	0.37717318	-.052	-.081	-.031	-.020	.033	-.200*	.025	0.643							
TC	98	3.407	0.39271834	.112	.004	-.143	-.047	.005	-.164	-.041	.565**	0.709						
WS	98	3.513	0.32721696	.051	-.057	-.089	.029	-.067	-.086	-.122	.415**	.636**	0.464					
AR	98	3.286	0.39089429	-.179	-.167	-.050	-.065	.308**	-.134	-.014	.239*	.194	.229*	0.382				
SPE	98	3.474	0.33909573	-.010	.027	-.250*	-.131	.050	-.152	-.017	.398**	.511**	.383**	.262**	0.407			
CRE	98	3.651	0.34733111	.043	.059	-.194	.024	-.093	-.161	-.069	.561**	.602**	.473**	.136	.534**	0.638		
COO	98	3.482	0.34428727	.123	.058	-.197	.077	-.154	.050	-.166	.360**	.556**	.521**	.053	.445**	.581**	0.465	
PP	98	3.859	0.42971767	-.020	.184	-.028	-.044	.094	.205*	-.016	-.017	-.011	.071	.134	.053	-.130	.065	0.755

Table 5 Means, Standard Deviations, and Correlations of All Variables in PLS Model

Cronbach's alpha and composite reliability and average variance extracted (AVE) are widely applied measurements for assessment of reliability. A threshold above 0.7 is widely considered to be acceptable for existing scales and a value above 0.6 is deemed appropriate for newly developed scales (Nunnally, 1978). The benchmark value for the composite reliability is recommended to be at least 0.7. For the first-order factor, the recommended minimal critical value for AVE is 0.5. The composite reliability and AVE values shown in Table 6 meet these criteria.

	AVE	**Composite Reliability**	**Cronbach Alpha**
PP	0.792	0.9195	0.8696
TMS	0.6803	0.8644	0.7647

Table 6 Reliability indicators

Agility, TMS, Task Variability and Project Performance

The results of the structural model are reported in Figure 2 and Table 7. First, the standardized path coefficient direct from agility to project performance is insignificant at $p < 0.1$ level (1.171). We can conclude a negative relationship between the two factors but not confirm the magnitude of the influence. Hence, H1 is inclusive which means agile practice solely cannot improve project performance. The path coefficient from agility to TMS is significant (0.665; $p < 0.01$), supporting the notion that agility has a positive impact on TMS supporting H2.

Hypothesis	**Relationship**	**Research Result**
H1(+)	Use of agile practices will positively influence software project performance.	Not support
H2(+)	Use of agile practices will positively influence transactive memory system.	Support
H3a(+)	Transactive memory system will positively influence software project performance.	Not support
H3b(+)	Transactive memory system will positively moderate the impact of the use of agile practices on software project performance.	Support
H4a(-)	Task variability will negatively influence software project performance.	Support
H4b(+)	Task variability will positively influence the use of agile practices.	Not support
H4c(+)	Task variability will positively moderate the impact of the use of agile practices on software project performance.	Not support
H4d(+)	Task variability and transactive memory system will jointly moderate positively the impact of the use of agile practices on software project performance.	Support
H5a(+)	The density of the initial knowledge network will positively influence the use of agile practices.	Not support
H5b(-)	The density of the initial knowledge network will negatively influence software project performance.	Not support
H5c(-)	The density of the initial knowledge network will negatively influence the density of the midterm knowledge network.	Support
H6a(+)	The density of the midterm knowledge network will positively influence the use of agile practices.	Not support
H6b(+)	The density of the midterm knowledge network will positively influence software project performance	Support

Table 7 Model Result

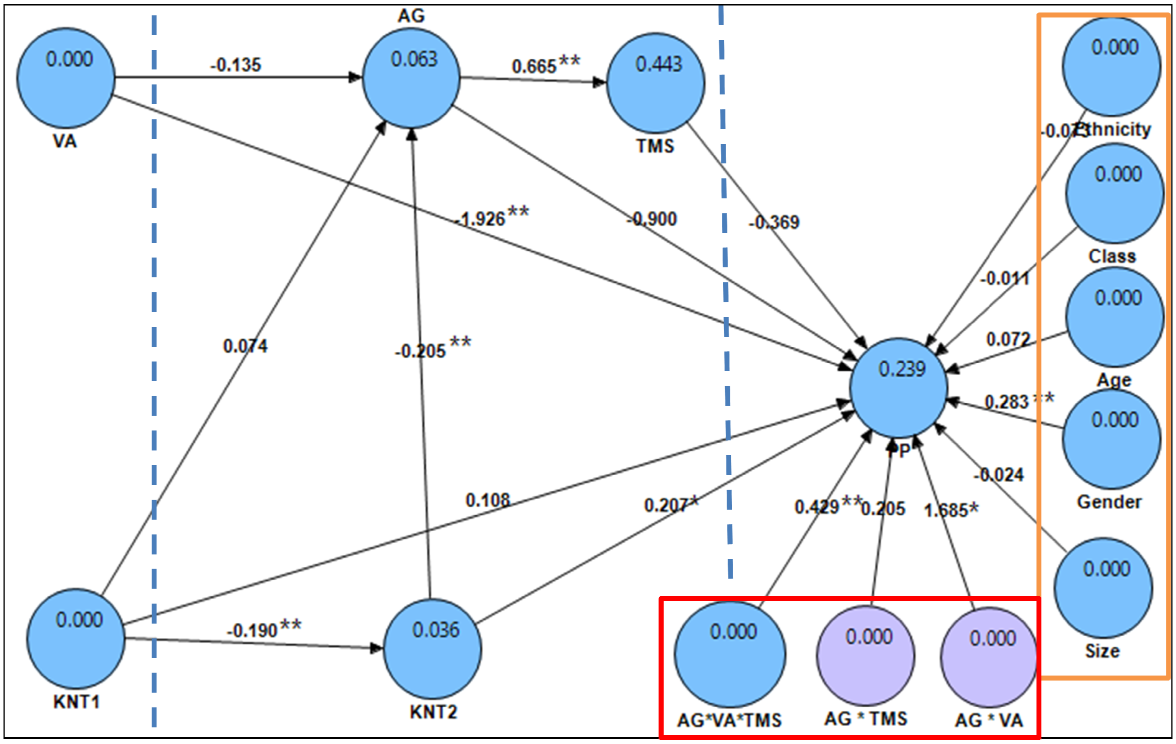

Figure 2 PLS Result of Path Coefficiency

** Significant at level p<0.01; * Significant at level p<0.05
Variables in red square represents moderation effect combination
Variables in origin square represents control variables

The causal relationship from TMS to performance is not statistically significant with the standardized path coefficient of -0.369 (p < 0.05). The results do not support to hypothesis H3a that TMS itself significantly contributes towards project. Hence, results indicate that neither TMS nor agile practice individually makes significant contributions to project performance. Different from all mentioned results, task variability diminishes project performance, since coefficients from variability to performance is -1.926 with p < 0.01srongly supporting H4a. One surprising finding in our model is the hypothesized positive relationship from variability to agile practice H4b. In PLS model, variability to agile practice shows negative standard path coefficient 0.135, although it is not significant.

The standardized path coefficients from Agility*TMS*VA to performance (0.429; p < 0.01) and from Agility*VA (1.685; p < 0.05) are both positive and statistically significant while moderation of TMS only is positive but not significant (0.209). Hence, H3b and H4d except H4c are supported with statistical power. From the result, we are confident to state that project performance is positively influenced by the combination development of agility and task variability with/without TMS.

Social Network

KNT1 shows significant and negative influence to KNT2 (-0.19; p < 0.01) but positive not significant to agility and performance (0.074, 0.108) respectively, which supports H5c not H5a. H5b supposes negative influence on performance, although it is not statistically powerful, our data shows positive effects. Therefore, initial knowledge network density may improve agility and project performance but definitely diminish midterm knowledge network density in our project sample. KNT2 shows the most interesting results. It significantly improves project performance supporting H6b, but also significantly decreases agile practice at the same time, which rejects H6a and opposes the original hypothesis we proposed. This allows for more opportunity for future research and discussion.

The path coefficients for two control variables are all insignificant (p < 0.1) except gender. The values for the path coefficient from team size, class location, ethnicity to performance are all negative without significance. Only gender diversity significantly increases project performance (0.283; $p < 0.01$). These insignificant path coefficients imply that most control variables do not influence the relationship in the proposed model.

The predictability of the model, reflected by the R^2 values, is another important determinant of the strength of the model (Chin, 1998; Komiak et al., 2004). The R^2 values for the variables in the proposed model are acceptable (2.9% for midterm knowledge network, 6.3% for agile practice, 44.3% for TMS, 23.9% for project performance).

CONCLUSION, FUTURE RESEARCH AND LIMITATIONS

Given the fact that there is no previous literature proposing the survey question on agility practice, we develop the four dimensions of agile practice based on the classical agility principle, as one contribution of this research. In individual level data, agility questionnaire components passed the first order CFA with certain level of reliability and validity. For a potential future research, more researches should be devoted to test of these items measurement in other scenarios.

Agility principle's contribution to performance is a complicated process. Agility cannot move the wheel of project performance forward by itself, and neither can TMS while task variability itself explains project performance. Task characteristics and TMS create the antecedence and consequence of flexibility and adaptation among group members. Without the previous two factors, agility seems useless or even harmful to project performance. Combined at least with task variability, agility plays the role of IPO process at team level to improve project performance. Our student sample supports that at group level agility improves ISD project performance, when and only when combined with task attributes of variability and optional TMS. Therefore our research question of usage context of agility is answered.

Network density shows interesting results: initial knowledge network support agile practice while midterm network, which support group communication and knowledge sharing, do not. The latter part is totally negative with powerful statistical support. One potential reason is that knowledge network density might influence agile practice in U-shape form. This is worthy of more future research with regression methodology. In performance relationship, initial knowledge network does not improve performance and midterm one does, which can be explained theoretically by norm and sharing logic in part. Therefore, we posit that initiation of knowledge sharing among group members did not work as prediction of agile practice while project attributes such as task variability struggle the agility in systems development on account of research questions.

In software project, project with lower variation and risk, such as existing popular software development is more appropriate for agile principles, which improves team flexibility and matches client expectation. During the project processes, satisfying performance of project not only depends on agility but also fluent knowledge sharing among project members. Team leaders are suggested to encourage sharing and discussion among members and follow the adaptive principle to customer's requirement in agile project.

There are also several limitations of this research. First, in factor analysis of Agility, critical value is 0.4 instead of 0.7, so all the agility structure in proceeding analysis is constrained to only one indicator illustration. Especially WS and AC dimension performs not completely satisfying and highly correlated with each other. More improvement should be done in item of agility formation. Second, more possible moderation effect of knowledge network is not testified and such loss of research. Third, student data might influence research results. And also more detail information is missing about sample, such as description of the students' specific experience in project management as our reviewer mentioned.

In summary, agile practice occupies task variability and TMS as a whole to improve information software design project performance. Meanwhile, in the envision phase of agile project, heavily dense knowledge network build overwhelming norm and routines and cut the interest to following network evolution in speculate, explore, adapt phases, and diminish agile practice finally. After networking orientation, active knowledge network build smooth sharing and creation which no doubt construct agility project value. The negative effect of midterm network to agile practice brings out one highly recommended future research to test the effect in detail, for example U shape.

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