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Differentiation and dynamism within the IT development program

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ABSTRACT

Information technology (IT) developments of large magnitude organize as collections of multiple projects into a single program, especially under dynamic conditions of market uncertainty that frequently change requirements or solutions midstream. Successful completion of an IT development program requires that the multiple teams work effectively together as well as independently in response to changes by relying on the differentiation of talent and knowledge available to the program manager. We consider and empirically support a model derived from principles in the multi-team systems (MTS) literature to determine the influence of differentiation among the IT program in the sharing of knowledge and information. The relationship from differentiation to program success is mediated by knowledge and information sharing, showing how to manage change through the dissemination of information and knowledge. Uncertainty of the market positively moderates the relation from differentiation among projects to information sharing. These findings contribute to the literature by empirically validating that MTS frameworks are exceptionally well suited for dealing with complex environments in the context of IT development.

1. Introduction

Large-scale information technology (IT) development systems are typically complex. Examples include software product lines for multiple clients and enterprise systems with multiple, unique modules. In these circumstances, an organization typically manages the entire development as a comprehensive program segmented into coordinated project teams, such that each project team manages a unique client in the product line or a single module in the enterprise system. Each project contributes to the overall achievement of the program but acts independently (Dingsøyr, Moe, & Seim, 2018). The IT development program must manage the multiple project teams that have interactive complexities of resources and

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competing interests of multiple stakeholders (Denyer, Kutsch, Lee-Kelley, & Hall, 2011). To effectively manage these interdependent projects, IT development programs could adopt multi-team system (MTS) principles (Dingsøyr et al., 2018). Program management with an MTS structure assembles independent project teams into a collective framework by grouping related projects together and centrally managing resources to achieve overall goals and deliver value (Artto, Martinsuo, Gemunden & Murtoaro, 2009). However, one must manage differences, such as goal discordance, competency separation, norm diversity, work process dissonance, and information opacity among the project teams to achieve better IT development performance (Luciano, DeChurch, & Mathieu, 2018), especially considering the challenges from changing requirements and technology throughout the development cycle. The problems in IT development programs, even in an MTS structure, remain a lack of interaction among projects and difficulty of inter-team coordination (Dingsøyr et al., 2018). These arise from an internal project focus on coordination with limited, often oral, communication within the teams, harming final development performance, such as cost overruns, late completions, and project failures (Flyvbjerg, 2014).

The literature on single-team and multi-team systems emphasizes goal consensus, organizational norms, work process design, knowledge sharing, and information access both in and across teams to assist coordination efforts and goal accomplishment (e.g., Faraj & Sproull, 2000; Firth, Hollenbeck, Miles, Ilgen, & Barnes, 2015; Lanaj, Hollenbeck, Ilgen, Barnes, & Harmon, 2013; Standifer & Bluedorn, 2006). In particular, “mutual knowledge reduces component teams’ need to discuss and clarify task-related issues with each other, thereby enabling them to implicitly and seamlessly coordinate efforts when working on joint tasks” (De Vries, Hollenbeck, Davison, Walter, & Van Der Vegt, 2016). However, MTS researchers have further found that a consensus in MTS will produce noticeable side effects, such as groupthink (Porck et al., 2019), group complacency (Luciano et al., 2018), and low aspirational behavior (Lanaj, Foulk, & Hollenbeck, 2018). These side effects channel teams to conduct their assigned work without coordinating activities, such as information sharing or knowledge sharing, reducing the active pursuit of common goals. In contrast, researchers imply that differentiation and diversity among the independent teams in MTS may motivate coordination across teams because of participative decision-making benefits (Lanaj et al., 2013) and reduced depletion (Porck et al., 2019). For example, De Vries et al. (2016) found that functional diversity, the differentiation of individuals concerning the functional domains in which they have obtained most of their work experience, contributes to horizontal coordination to improve performance. Beyond the individual-level differentiation, this study focuses on team-level differentiation in IT development MTS and proposes the first research question: *whether the differentiation among teams within IT development MTS contributes to coordination and further improves final IT development performance?*

Aside from differentiation in MTS, dynamism is another important characteristic describing variability and instability over time. Dynamism is instability in the environment that alters system requirements over the short and long term. Dynamism of the market, technological advances, and regulatory environment are critically important in MTS theory as dynamism embraces temporal and dynamic complexities (Luciano et al., 2018). In the context of IT development, changing customer requirements due to market uncertainty is one critical source of dynamism. In a dynamic environment, differentiation and diversity, including size and functional specialization of multi-team systems, provide more resource maneuverability than stand-alone teams (Porck et al., 2019 Lynn, 2005), which further provides more flexibility and makes MTS suited for complex environments (Zaccaro, Marks, & DeChurch, 2012). However, the benefits of differentiation will be at the expense of communication costs and resource depletion, which may then reduce motivation to coordinate across teams in the MTS. Therefore, Lynn (2005) argues that external uncertainty should be matched with a requisite internal variety to achieve the best performance. In the context of IT development, when market uncertainty is high, differentiation consumes resources better utilized to achieve coordination. Therefore, we propose the second research question: *whether the changing requirements due to market uncertainty will enhance the effectiveness of differentiation among teams within IT development MTS on coordination?*

To answer the proposed research questions, this study adopts a framework of MTS with two overarching aspects - differentiation and dynamism - to theorize the positive effect between differentiation, coordination among IT development teams, and final performance as moderated by market uncertainty. Based on a survey and analysis of 110 IT development programs with an MTS structure, results suggest that two coordinating mechanisms (information sharing and knowledge sharing) mediate the effectiveness of MTS differentiation on IT development performance. Further, market uncertainty will increase the effectiveness of differentiation on information sharing but not on knowledge sharing. These findings provide important contributions to the MTS literature by: 1) confirming the positive role of differentiation among IT development teams in an MTS consistent with the idea of depletion from social identification (Porck et al., 2019); and 2) identifying the importance of information sharing among IT development project teams in an MTS under the condition of market uncertainty. Together 1 and 2 provide a perspective that explains why multi-team systems are exceptionally well suited for dealing with complex environments.

2. Theoretical background

2.1. MTS framework

The framework of MTS has two overarching aspects-***differentiation*** and ***dynamism*** (Luciano et al., 2018). First, each component team has its task responsibility, which might lead to incongruent processes across component teams. Differentiation is the degree of difference and separation between MTS component teams (Luciano et al., 2018). Second, the component teams must respond to uncertainty throughout the component teams. Dynamism is the variability and instability of an MTS over time (Luciano et al., 2018). These two key aspects of MTS are the shape of the structure and how it changes over time. Theoretically, differentiation in MTS will lead component teams to experience serious fractions and boundary reinforcement between teams (Luciano et al., 2018). Dynamism in MTS infuses uncertainty and destabilizes the system, which undermines effective MTS functioning.

Differentiation originates from multiple sources such as goal discordancy, competency separation, norm diversity, work process dissonance, and information opacity among component teams (Luciano et al., 2018). The effect of these five potential sources of differentiation can be combined to reinforce the boundary strength among component teams. In IT development programs, because each project is a specialized team that owns different knowledge and capabilities, there is a need to enrich inter-team work by encouraging all projects to leverage their knowledge and information for collective task completion. In particular, competency separation and work process dissonance maintain component team distinctiveness even though they must cooperate on system goals. For example, in enterprise system development, members of component teams from different functional areas may reinforce team boundaries by championing their frames-of-reference and solution approaches in discussions about how IT development is to be accomplished. They design workflows to align to their functional areas and interpret inputs and outputs of other component teams from their functional perspectives. As a result, functional separation and work process dissonance are significant sources of differentiation among component teams in an IT development program. In this study, we use the effort for one IT development project team to make other project teams to understand its component system as a proxy to capture differences.

Dynamism originates from multiple elements, including changes in goal hierarchy, the uncertainty of task requirements, the fluidity of system configuration, the fluidity of system composition, and diversion of attention (Luciano et al., 2018). Similarly, each dynamic element is a source of variability and infuses uncertainty into the MTS. Managers in the IT development program must consider the resulting uncertainty despite multiple stakeholders with differing and often conflicting expectations (Thiry, 2002, 2004). A large-scale IT development tends to be a long-term endeavor, and the trend of market demands may change significantly during the IT development lifecycle. Most importantly, customer needs and expectations may evolve as well. Market uncertainty is challenging in regards to defining updated IT features and functionality that deal with demand variations. Here, market uncertainty is ongoing changes and unpredictability of requirements due to market pressure. The contextualization of differentiation and dynamism in IT development program is summarized in Table 1.

2.2. Boundary-related coordination

Differentiation is the fundamental reason to structure an MTS in order to accomplish complex tasks by coupling specialized component teams to targeted work in achieving integrated system goals (Marks, DeChurch & Zaccaro, 2012; Zaccaro et al., 2012). Although high differentiation creates divides among component teams and harms overall performance, Davison, Hollenbeck, Barnes, Sleesman, and Ilgen (2012, p. 821) indicate that “teams that enact differentiated team roles as a mechanism to achieve coordination consistently outperform teams that act like one large undifferentiated team.” Therefore, differentiation should be effectively managed through boundary-related coordination to decrease the relative heterogeneity across component teams. MTS boundary-related coordination primarily centers on sharing activities relating to accomplishing individual team tasks and simultaneously involving learning activities related to interactive assistance for MTS success. Dietrich, Kujala, and Artto (2013) suggest that inter-team coordination is an information-processing activity, closely related to communication and shared meaning, which can offset the heterogeneity caused by differentiation.

An MTS involves high interdependence on complex tasks. If communication of change is late, or the information is unclear on the interdependent tasks, rework is likely to be necessary (Hoegl, Weinkauf, & Gemuenden, 2004). Besides, MTS is a distributed knowledge system, where data, documents, information, and knowledge reside in many locations and many teams. Information and knowledge sharing provides a way to connect the diverse sources that are relevant for accomplishing a collective set of tasks. Boundary-related coordination in an MTS typically involves the specification and operation of information-sharing, regular meetings, and mutual learning in the relationship to combine information and knowledge in productive ways (Dietrich et al., 2013). Given differentiation among the component teams in an MTS, it is critical to exchange information and knowledge to ensure that the right information and needed knowledge reaches each relevant component

Table 1
Differentiation and dynamism in IT development program context.

	MTS theoretical concepts	IT development program context
Differentiation	The degree of difference and separation in terms of goal, competency, norm, work processes, and information between component teams in MTS (Luciano et al., 2018).	IT development programs generally incorporate technical and organizational complexity. It includes a wide range of competencies such as programming, data architecture, and interface design that are required in IT development and often has complex task interdependencies since projects depend on inputs and outputs from and to others.
Dynamism	Dynamism in MTS describes the variability and instability resulting from a change in goals and requirements, the fluidity of configuration, and composition and diversion of talent over time (Luciano et al., 2018).	Changes in market trends and customer needs pose challenges for IT development programs. Market uncertainty contributes to the lack of ability and unpredictability in specifying requirements, leading to adaptation problems among projects.

team. We conceptualize MTS boundary-related coordination as the ***information sharing on interdependent development tasks*** and ***knowledge sharing on lessons and experiences from development processes*** required for integrating competencies and managing interdependencies. More specifically, ***information sharing*** is activity to disseminate the interdependent requirements to all levels and teams in the IT program, such as assigning and sharing data, distributing official reports and program documents, conducting formal meetings, and holding regular conversations. However, it is further imperative that component teams apply experience gained from the past to similar tasks, and share lessons learned with other teams. Thus, as a complement to information sharing, ***knowledge sharing*** is the activity to disseminate domain knowledge, experience and learned lessons from one program team to other teams, such as implementing policies or procedures for the provision of domain know-how and developmental experience. Indeed, MTS differs from traditional departmentalized structures, in that system goals require more intensive reciprocal interdependence between teams, such that outputs of each team can become the inputs for others (Shuffler & Carter, 2018). The complexity of IT development programs also requires reciprocal interdependence between projects, which means that highly differentiated projects need to interact through mutual adjustment processes, such as the exchange of essential information and knowledge (Scheerer, Hildenbrand, & Kude, 2014).

3. Research model and hypotheses development

As individual projects become more specialized, we argue that boundary-related coordination, such as information and knowledge sharing, should be introduced as a compensatory mechanism to help projects contend with the boundary-enhancing and disruptive forces caused by differentiation and market uncertainty. We suggest managing differentiation in the amount of market uncertainty through information and knowledge sharing that helps achieve IT program success. The proposed model in Fig. 1 emphasizes the impact of differentiation on program performance through information sharing and knowledge sharing, while dynamism as market uncertainty moderates the direct effect of differentiation on information sharing and knowledge sharing.

Differentiation generates boundary-enhancing (i.e., the distinctions among component teams), which requires boundary-related coordination among projects to encourage each project to orient toward the program as opposed to the individual team (Luciano et al., 2018). Differentiation between teams within the IT program, concerning their functions and corresponding business processes, can severely limit the ability to sequence their interdependent tasks effectively (Shuffler & Carter, 2018). There is a clear need for synchronizing teamwork processes across teams. Inter-team information and knowledge sharing are important for accomplishing specific tasks and for offering the opportunity to ensure all interdependencies among teams operate in congruence. On the one hand, higher differentiation between teams within the IT program means more information asymmetry. Given these teams have interdependent system modules, modules located across teams must integrate for the final IT product. The information asymmetry and opacity caused by differentiation will motivate these teams to share information (Luciano et al., 2018), especially during the stage of transition of one project deliverable to other project teams. Thus, component teams need to discuss and exchange task-related information with each other (De Vries et al., 2016). Otherwise, component teams will not be able to deliver collective outcomes given they do not sufficiently understand each other's specialized task competences, resources, and constraints (Cramton, 2001; Kotha, George, & Srikanth, 2013; Srikanth & Puranam, 2011). Therefore, we hypothesize:

H1. Differentiation will have a positive effect on information sharing

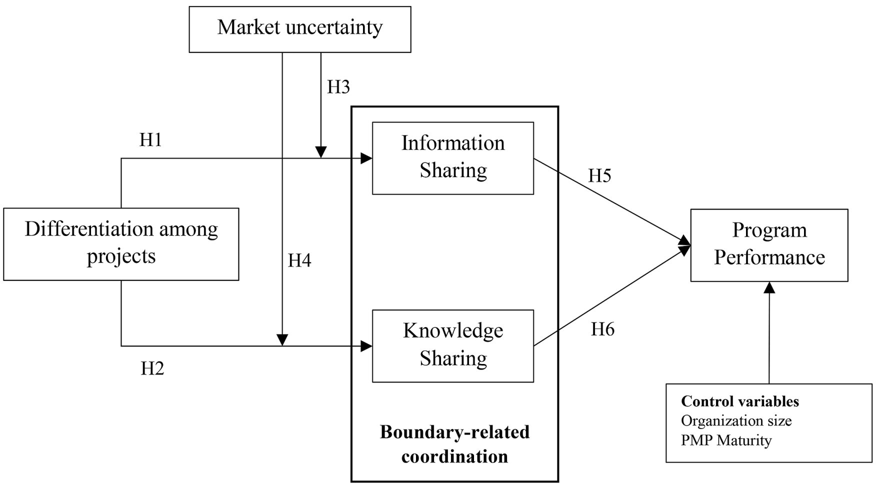

Fig. 1. Research model.

On the other hand, higher differentiation means individual projects become more specialized and often develop respective system modules in the order of their importance. However, more specialized knowledge embedded in one system module represents greater necessity, and greater difficulty, to share knowledge of coordinated development (Ratcheva, 2009). Also, although multiple teams in the program may differ in their functional requirements, the lessons of experience on IT development learned in one project team are often valuable for subsequent system module development in other teams (Hällgren & Maaninen-Olsson, 2005; Park & Lee, 2014). As Fernie, Green, Weller, and Newcombe (2003) relay, different teams in the same context or organization often share necessary knowledge for efficient teamwork. Therefore, we argue that:

H2. Differentiation will have a positive effect on knowledge sharing

Uncertainty expands as does interdependence (Gresov, 1989; Tushman, 1978, 1979), resulting in an increase in requirements and need for information coordination among interdependent units (Hällgren & Maaninen-Olsson, 2005; Perminova, Gustafsson, & Wikström, 2008; Tushman & Nadler, 1978). The literature suggests that market uncertainty increases the complexity and turbulence of the external environment, and makes a firm's functional departments more dependent on each other for expertise, information, and other resources (Song et al., 2001). MTS in highly turbulent environments place a premium on their ability to respond rapidly to changing circumstances by changing the requirements of the anticipated IT product; thus, information processing is reciprocal and intense among component teams to update predictions and align efforts (Mathieu et al., 2001). The general premise is that component teams experiencing uncertainty should have difficulty deriving inferences because they lack the information necessary to identify and interpret market or technical cues and adjust requirements. Indeed, frequent improvements in IT functionalities and changes to system designs in response to market uncertainty creates significant information needs for the interdependent teams. Thus.

H3. The effect of differentiation on information sharing will be positively moderated by market uncertainty

In addition, the interdependent teams of the IT program should share their understanding of the situation because the different understandings affect the way a team "makes sense" of a new situation and decides on alternative actions (Perminova et al., 2008). The way uncertainty is perceived by the different teams depends on the different skills, intuition and judgment of the team members. A higher differentiation among IT program teams will mean further separation of understanding about market uncertainty across teams, which should motivate higher knowledge sharing. In particular, more changes to requirements should also produce more experience and lessons to share among the teams in the IT program (Hällgren & Maaninen-Olsson, 2005). Thus, we argue that:

H4. The effect of differentiation on knowledge sharing will be positively moderated by market uncertainty

Inter-team information and knowledge sharing are as important for accomplishing specific tasks and for offering the opportunity to ensure all interdependencies among teams operate congruently, which improves performance (Chiocchio et al., 2011; Hällgren & Maaninen-Olsson, 2005). In this study, MTS in an IT program with high differentiation will experience greater fractioning and boundary reinforcement between teams. Information sharing, in turn, may promote team performance by preventing redundancies and inconsistencies between different component teams' activities (Hoegl et al., 2004; Lanaj et al., 2013). In addition, component teams may receive crucial support from each other through sharing activities, which enable them to execute key tasks better and set more realistic goals for the system as a whole (Joshi, Lazarova, & Liao, 2009; Marrone, 2010). Information sharing is an effective activity to reduce the information asymmetry and opacity, thus.

H5. Information sharing will have a positive effect on IT development program performance

Increased levels of knowledge sharing in integrated problem solving between specialized teams takes advantage of external knowledge and expertise to enhance the system development process (Scheerer et al., 2014). Knowledge sharing enables specialized teams to exploit lessons learned in previous work by exchanging advice through informal communities of practice (Brown & Duguid, 2001). Knowledge sharing offers the opportunity of exchange with experts from other teams, where new perspectives and alternative ideas cross into the team (Barczak & Wilemon, 1991). Therefore, knowledge sharing will empower the team with knowledge to tackle development problems and streamline the workflow for better performance (Dingsøyr et al., 2018). Thus.

H6. Knowledge sharing will have a positive effect on IT development program performance

4. Methodology

4.1. Measurement

The psychometric properties of the measurement items posited to reflect the theoretical constructs were refined through a series of interviews with a convenience sample of program managers and academic experts. The objective of this refinement process was to ensure that the scale items were meaningful in the NPD context and unambiguously captured the domain of each construct. The contextual descriptions of the research constructs in Table 2 serve as a starting point for scale development. Due to the sample, the survey required translation to Chinese. The translation work was done by a researcher and

Table 2
Construct definition.

Construct	Definition	References guiding construct conceptualization
Differentiations	The effort for one project team to make other project teams to understand its subsystem in the IT program.	Luciano et al. (2018)
Information Sharing	The activities to disseminate the interdependent requirements to all levels and teams in the program.	Mesmer-Magnus and DeChurch (2009)
Knowledge Sharing	The activities to disseminate domain knowledge, learned lessons, and experience in one program team to other teams.	Dingsøyr et al. (2018)
Market Uncertainty	The changes and unpredictability of customers' IT requirements due to market pressure.	Song, Xie, and Di Benedetto (2001)
Program Performance	The extent to which the new IT product meets client requirements of scope and delivery	Parolia, Jiang, Klein, and Sheu (2011)
Organization Size	Number of full-time employees	Kopp and Litschert (1980)
PMP maturity	The percentage of full-time employees with PMP qualifications	Wierschem, Zhang, and Johnston (2010)

confirmed by a second researcher fluent in both English and Chinese. Next, two experienced program managers reviewed the Chinese language survey for clarity. In order to establish the face and convergent validity, we conducted a two-step Q-sorting by ten Ph.D. students in the College of Business of a large university in southeastern China to secure all facets of a construct are included, and the items for a construct are convergent (i.e., Salvador, Chandrasekaran, & Sohail, 2014; Tang & Rai, 2012). The two separate rounds of sorting (five sorters in each round) purify the previously generated items, in which sorters classified items based on their similarity with definitions and descriptions of underlying construct categories. For round 1, the correct rate of item-to-construct definition classifications was around 80%. After minor corrections based upon the agreement between sorters' classifications, the modified items were classified by another group of five sorters for round 2, during which they successfully classified 90% of the items into the intended constructs. The improvements indicated the establishment of face and convergent validity.

Having confidence that the items were reliable, we moved to pilot test the survey on our target population. We selected IT development program managers from the IT industry because they were the most knowledgeable about the structural properties in the IT development project. The survey was pilot-tested on a convenience sample of twenty program managers who had experience in customized IT development programs. The items were minimally modified based upon feedback. Final items were on a five-point Likert-scale with anchors ranging from 'strongly disagree' to 'strongly agree' for all, except for resource interdependence anchored from 'not at all' to 'extensive.' All the measurement items appear in Appendix A.

4.2. Data collection

A survey method was selected to collect data and empirically test the proposed model. The unit of analysis is at the inter-component team level. Data collection is through a multi-source research design. Each participating company will assign its own IT program manager as the leader for managing the IT development program. IT program managers and their subordinate project managers are the informants. They are the most important participators in leadership positions comprising boundary spanning activities and system-wide responsibilities for the IT development program. One select project manager was the representative for all the projects involved in the IT development process, while the chosen program manager was the person accountable for managing and structuring the program. The survey targeted 500 randomly sampled IT companies in China. Invitation mailed to the 500 companies requested participation in the research project. Of the 500 sampled companies, 320 indicated a willingness to participate. Companies that agreed to participate appointed a survey coordinator to serve as the liaison with the research team. A questionnaire package, including a cover letter with instructions, the survey, and postage-paid return envelopes, was sent to the coordinator.

Program managers are in charge of the whole IT development program, and they are in a leadership position to answer the constructs relating to dynamic environments. To get accurate responses, instructions to the program managers required selection of a single IT development recently completed program and provision of answers based on the program selected. Once they finished the questionnaire, they were requested to identify a key project manager from their IT development program. The project manager accounts for significant portions of the developmental performance. The project manager would be more familiar with the level of information sharing and knowledge sharing achieved while completing the required tasks. Further, they are more familiar with the structures in place for the IT development program such that they can answer questions about the level of differentiation and the consequences of the interrelationships among the component teams. The use of two informants reduces potential problems arising from a single informant such as common method variance. Follow-up calls and reminder emails were sent two weeks after the initial contacts, resulting in a collected sample of 132 responses. We used unique identification numbers to match the two different informants for each program and filtered incomplete responses. Out of those received, 22 surveys were discarded due to incomplete responses. The remaining 110 observations compose the final sample and appear in all analyses. The useable response rate was 22%, which is comparable to other studies adopting a matched-pair survey from senior executives (Lu & Ramamurthy, 2011). A power level of 0.8 in PLS-SEM with an alpha value of 0.05 was specified to calculate the minimum required sample size that satisfies the 25% anticipated effect size. Under these conditions, 65 is the minimum required sample size for the model structure (Hair Jr, 2016). In order to examine the degree of potential bias, we used late respondents as surrogates for a sample of non-respondents and compared the differences in the means of early respondents and late respondents on key constructs. The results indicated that there was no significant difference in the key constructs between early respondents and late respondents.

5. Data analysis and results

We used the partial least squares (PLS) approach for data analysis. The primary research objective and model characteristic justified the choice of the PLS approach over a covariance-based SEM (CBSEM) approach (Hair et al., 2012; Peng & Lai, 2012). PLS analysis is appropriate for this study because it is the first study to examine the relationship between program differentiated structure and program performance, with a potential nonlinear effect among differentiation, market uncertainty, information sharing, and knowledge sharing in the context of IT development programs. We attempt to assess the predictive validity of the effect of differentiation on information sharing and knowledge sharing, making PLS an appropriate analysis technique by maximizing the explained variance of the dependent variable and provide better advice for practice that depends on predictive models (Chin, 1998; Hair et al., 2012; Hair & Sarstedt, 2019; Peng & Lai, 2012). The use of CBSEM to test nonlinear relationships among latent variables remains unclear because the distributions of the latent nonlinear terms are likely not normal. As simulation studies have clearly shown, using the maximum likelihood estimation method of the CBSEM with non-normal product terms leads to a serious underestimation of standard errors and biased chi-square values even for models with only one latent interaction term (Marsh, Wen, & Hau, 2004). While PLS uses iterative method estimates factor loadings and structural path coefficients separately, which allows the researcher to consider complex relationships in the structural model better. The literature suggests that using PLS can have a superior ability to detect the magnitude of moderation effects in the structural model (Helm, Eggert, & Garnefeld, 2010; Peng & Lai, 2012). In sum, this study used the PLS approach with Smart PLS 2.0 software to test the proposed model. Statistical evidence of both convergent validity and discriminant validity derive through the measurement model. The estimation of path coefficients for the hypothesized paths result from the structural model.

Composite reliability is an estimate of reliability when using an SEM approach. Previous studies acknowledged that the SEM approach could perform better estimates of true reliability than possible through Cronbach's alpha because item loadings are allowed to vary, whereas the loadings for Cronbach's alpha are constrained to be equal (Peterson & Kim, 2013). Table 3 contains a summary of the results of composite reliability for each construct. For discriminant validity, the square root of AVE for each construct should be higher than all inter-construct correlation coefficients with the construct as well as the correlation between any pairs of constructs should be below 0.8 (Fornell & Larcker, 1981).

Table 4 showed the correlation table between each construct whose diagonal numbers are the square roots of AVE. In summary, the above results support convergent and discriminant validity.

A bootstrapping procedure with a re-sampling of 5,000 samples tested the structural model to determine the statistical significance of the hypothesized paths. The product indicator approach established any interaction effect of differentiation with information sharing and knowledge sharing. The product terms served as indicators of the moderating variable in the structural model. The results are in Fig. 2. The paths examining the relationship between differentiation with information sharing and knowledge sharing were both positively significant. The results provided statistical evidence to support H1 and H2.

Controlling for the main effect of differentiation among projects in the program, the interaction effect of market uncertainty and differentiation has a positive effect on information sharing, whereas the interaction effect of market uncertainty

Table 3
Convergent validity and reliability.

Construct	Items	Loadings	t-value	Composite Reliability
Differentiation	DI1	0.922	25.92	0.94
	DI2	0.920	26.96	
	DI3	0.891	24.01	
Information sharing	IS1	0.635	3.25	0.67
	IS2	0.640	3.51	
	IS3	0.619	4.38	
Knowledge sharing	KS1	0.880	28.51	0.88
	KS2	0.812	17.41	
	KS3	0.830	15.89	
Program performance	PP1	0.681	7.79	0.86
	PP2	0.892	20.03	
	PP3	0.879	17.58	
Market uncertainty	MU1	0.727	2.42	0.78
	MU2	0.666	2.16	
	MU3	0.618	3.01	
	MU4	0.729	3.14	

Table 4
Discriminant validity.

Construct	DI	IS	KS	PP	MU	Size	Maturity
Differentiation	**0.83**						
Information sharing	0.44	**0.63**					
Knowledge sharing	0.25	0.41	**0.84**				
Program performance	0.21	0.37	0.38	**0.68**			
Market uncertainty	0.09	0.17	0.38	0.33	**0.69**		
Organization size	−0.02	0.06	0.08	0.02	0.00	**NA**	
PMP maturity	0.13	0.15	0.20	0.26	−0.09	−0.17	**NA**

Bolded diagonal elements are the square root of average variance extracted.

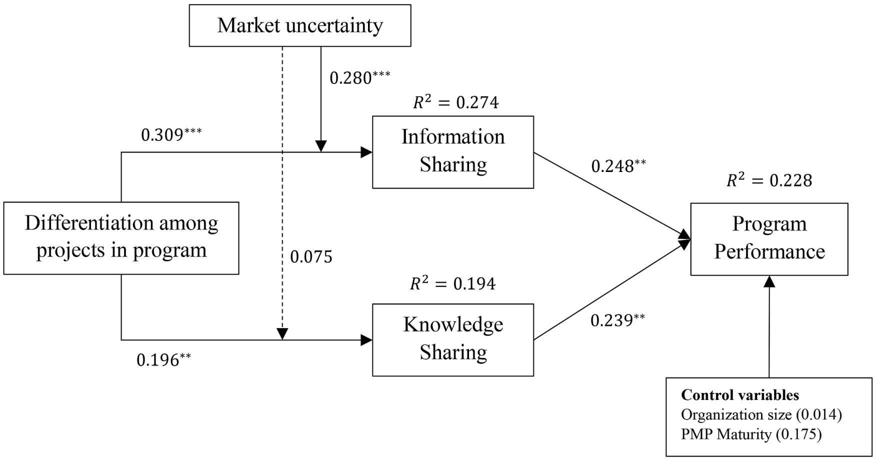

Fig. 2. Results of the structural model.

and differentiation does not affect knowledge sharing. Thus, the effect of differentiation on information sharing will be positively moderated by market uncertainty, but its effect on knowledge sharing will not be moderated by market uncertainty. The results provided statistical evidence to support H3. Last, the relationship between information sharing and program performance was positively significant. The relationship between knowledge sharing and program performance was also positively significant. The results provided statistical evidence to support H5 and H6. The values of R^2 appear in the structural model of Fig. 2 with the model showing an explained variance of 22.8% for program performance. Moreover, we used Stone-Geisser's Q^2 to assess the predictive relevance of the model, using a blindfolding procedure. The value of Stone-Geisser's Q^2 was 0.366 for program performance. The results support predictive relevance and confirm the nomological net between differentiation and program performance.

6. Discussion

This study first conceptualizes the sharing of knowledge and information between IT project teams as partially dependent on the differentiation among IT development teams in an MTS structure and then captures market uncertainty forced changing requirements and technology during the IT development process to conceptualize the source of dynamism in IT development programs. Particularly, information sharing and knowledge sharing are conceptualized as two different MTS boundary-related coordination mechanisms. Based on Luciano et al.'s (2018) MTS framework with two overarching aspects - differentiation and dynamism - we examined the positive mediation role of both information sharing and knowledge sharing on the relationship between differentiation and final IT development performance and the positive moderating effect of market uncertainty on the effect of differentiation on the two coordination mechanisms. After the data analysis of 110 IT development programs with an MTS structure, results confirmed that differentiation improves the final IT development performance via both coordinating mechanisms (information sharing and knowledge sharing). However, market uncertainty will improve only the effectiveness of differentiation on information sharing - not on knowledge sharing. These findings provide important contributions and implications for future MTS researchers.

6.1. Research implications

The first important implication for MTS researchers is paying more attention to the positive role of differentiation among teams in IT development MTS. Prior research emphasizes that high differentiation will create divisions between component teams and harm overall performance. However, Davison et al. (2012, p. 821) indicate that "teams that enact differentiated team roles as a mechanism to achieve coordination consistently outperform teams that act like one large undifferentiated team." For example, De Vries et al. (2016) found that interpersonal functional diversity considering differentiation within individuals, which reflects differences across members with regard to the functional domains in which they have obtained most of their work experience, will contribute to horizontal coordination and further improve performance. Extending their work, this study confirmed the positive role of team-level differentiation on the MTS boundary related coordination and further IT development MTS performance. Based on the team and MTS literature we could explain to some extent the positive effect of differentiation, instead of the detrimental group think, group complacency, and lower aspirational behavior (Lanaj et al., 2018; Luciano et al., 2018; Porck et al., 2019). Differentiation becomes the fundamental reason to structure as an MTS in order to accomplish complex tasks by coupling specialized component teams to work toward an integrated system goal (Mathieu et al., 2001; Zaccaro et al., 2012). Therefore, differentiation in an MTS is a double-edged sword, and future MTS researchers should pay more attention to its positive role while at the same time to reduce any detriments. For the positive role of differentiation, this study mainly focused on the mechanism of information sharing and knowledge sharing but it is limited to our conceptualization on differentiation as the effort between interdependent teams to understand respective component systems in the IT program. Future studies could have different conceptualizations on the differentiation in our IT development context or other MTS context. For example, Lanaj et al. (2018) conceptualized differentiation as the divergent risk preferences between leadership and component teams in the context of a leadership training course of the United States Air Force. They found the MTS with high differentiation will inspire more aspirational behavior and better performance.

The second important research implication is the difference between information sharing and knowledge sharing as two types of MTS boundary-related coordination mechanisms in future inter-team coordination researches. During the IT development process, data, documents, and information are not concentrated in a single team but distributed among multiple teams. Therefore, the effective MTS operation will require effective information sharing to avoid information opacity (Luciano et al., 2018). On the other hand, a coordinated sharing among teams in the IT development MTS will create knowledge from experience and lessons of the individual project teams, which should minimize the cost of collective trial and error (Myers & Cheung, 2008). Particularly, maximum benefit requires integration of the fragmented knowledge distributed among the IT development project teams (Myers & Cheung, 2008). Based on the work of Alavi and Dorothy (2001), "information" in this study could be considered as one type of "explicit knowledge" because interdependent IT development requirements have been articulated and presented in the form of text, graphics, words, or other symbolic forms. However, "knowledge" in this study is closer to their "tacit knowledge" of domain knowledge, lessons learned, and experience during IT development. Among them, domain knowledge belongs to the technical elements of tacit knowledge and experience belongs to the cognitive element. Although two sharing activities on information and knowledge are both found important in the IT development MTS, our findings also show their difference under the condition of market uncertainty given information sharing will play a greater role during market uncertainty. This difference may result from uncertainty evolving in an ongoing fashion, and the information required to respond appropriately and in a timely fashion is generated during the program from multiple sources but required for teams to remain consistent on their interdependent activities. However, knowledge is more static in the teams. Future MTS researchers could further explore the important condition between differentiation and knowledge sharing to determine the use of knowledge repositories in a dynamic environment. The task complexity in Porck et al.'s (2019) work may be one possible perspective because task complexity requires more knowledge coordination among the development teams, perhaps structured to a system based on just-in-time requirements.

Finally, this study provides empirical backing on why multi-team systems are exceptionally well suited for dealing with complex environments from the differentiation perspective. Given our conceptualization of the environment uncertainty being changes of interdependent IT module requirements that capture the IT development MTS's dynamics, higher uncertainty will create more information asymmetry in the IT development program. In this situation, a higher differentiation will require more information sharing among the program to eliminate the information asymmetry among teams in the program and align their development work. Lynn (2005) argued that "when organizations mirror the complexity of their environments, organizational members are better able to understand, predict, and respond to environmental forces." Therefore, differentiation providing requisite variety occurs when the organization follows the complexity of its environment - so differentiation provides more flexibility for the IT development MTS to better monitor, interpret, and react to environmental change and exchange information about changes (Porck et al., 2019 Lynn, 2005). However, one should note that the benefits of differentiation will be detrimental to communication costs and resource efficiency, and may reduce the motivation of coordination among the teams in the MTS. Therefore, external uncertainty should be matched to internal differentiation to achieve the best performance. Excessive high differentiation will take up more resources, but too low a differentiation will disenable the MTS to respond to the uncertain environment. Therefore, it will be interesting to explore the best match between differentiation and uncertainty to achieve the best performance in future research. Further, results of this study only consider the dynamics of MTS from changing requirements, future researchers should further compare the role of different sources of dynamism in MTS, including changes to goal hierarchy, uncertainty of task requirements, fluidity of system configuration, fluidity of system composition, and diversion of attention (Luciano et al., 2018).

6.2. Practical implications

There are also important implications for practical IT development. First, the MTS should be adopted more often for large-scale, complex IT/IS development. The multiteam structure provides more flexibility to effectively develop distributed system modules and integrate them for overall functional goals. However, the differentiation among teams in the IT development MTS must respond to external conditions. Securing a broad knowledge base achieves differentiation that should optimize resources and maintain the capability to respond to unexpected change. Finally, although information sharing and knowledge sharing are both boundary-related coordination activities, they have different orientations. IT development programs must structure effective collection and dissemination of current information about the environment.

7. Conclusions

Our survey-based study considers a model of differentiation among project teams in an IT development program. Specifically, differentiation is the diverse knowledge and differing backgrounds across teams reflected in the efforts required to share essential information understandably. The hypotheses supported indicate that differentiation leads to higher levels of knowledge and information sharing across teams, which then mediate the relationship to program performance. Market uncertainty, which represents the changes required of the IT developers required due to changes in the environment, positively moderates the relationship between differentiation and information sharing but not differentiation and knowledge sharing. The results affirmatively answer the research questions of whether the differentiation among teams within IT development programs contributes to coordination and further improves final IT development performance and whether the changing requirements and technology due to market uncertainty will enhance the effectiveness of differentiation among teams within IT development programs on coordination? As such, the study implies that researchers and practitioners should consider differentiation as a positive feature of IT development programs organized into a multi-team system. Further, it is important to consider information sharing and knowledge sharing as separate functions, with a need to establish appropriate processes for each, especially for information sharing of current information under greater conditions of uncertainty.

Conflicts of Interest

The authors declare no conflict of interest.

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Appendix A. Measurement items

Differentiation among projects in the program

DI1: When we share our project deliverables with other projects in this program, it requires a larger amount of effort for us to explain the attributes of the developed subsystem.
DI2: When we share our project deliverables with other projects in this program, it requires a larger amount of effort for us to explain the proper usage procedure.
DI3: When we share our project deliverables with other projects in this program, it requires a larger amount of effort for us to illustrate the variety of uses of the developed subsystem.

Information sharing

IS1: Each project must exchange a number of data elements with other projects in this program in order to understand their requests.
IS2: Project managers in this program frequently meet with each other to discuss the system requirements.
IS3: Test data and market data disseminate through formal channels to all levels in this program.

Knowledge sharing

KS1: Project managers have specific mechanisms for sharing lessons learned in this program.
KS2: The program manager of this program repeatedly emphasizes the importance of sharing domain knowledge.
KS3: Project managers in this program put great effort into sharing lessons and experiences.

Program performance

PP1: The program generated a range of outputs to various client needs.
PP2: The IT product meets customer expectations for response time, flexibility and ease of use.
PP3: Users of the IT product produced by this program are satisfied with the overall quality.

Market uncertainty

MU1: In terms of IT product functions, future customer needs are dynamic and difficult to predict.
MU2: In terms of IT product performance, future customer preferences are dynamic and difficult to predict.
MU3: The IT product market is under great pressure, the environment is changing and highly competitive, which is difficult to cope with.
MU4: An unpredictable sequence of steps must be followed for developing an IT product to meet future demands.

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