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RESEARCH PAPER

Software Quality and Development Speed in Global Software Development Teams

The Role of Previous Working Ties and National Diversity

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Abstract The paper draws on information processing theory to propose that national diversity creates barriers to the integration of information among members of global software development teams, negatively impacting software quality and development speed. However, the effect of such relationships was expected to be contingent upon the amount of time that team members had worked together in the past (i.e., previous working ties). Hypotheses were tested in a field study involving 62 global software development teams distributed across Europe and Central and South America. Teams with high levels of previous working ties developed greater quality software at a faster pace. National diversity had a positive effect on software quality in teams with high levels of previous working ties, but a negative effect in teams with low levels of previous working ties. National diversity also had a negative impact on software development speed, but the effect was less pronounced among teams with high levels of previous working ties than on teams low in previous working ties.

Keywords National diversity · Previous working ties · Global software development teams · Global teams · Information processing theory

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1 Introduction

Global teams are formed by individuals who have different cultural backgrounds, social norms, and native languages, as well as different approaches towards teamwork, power relations, and deadlines (Hofstede 1983; Walsham 2002). In the presence of such diversity, exchange and integration of information is usually difficult, time-consuming, and prone to errors (Shachaf 2008; Stahl et al. 2010), which can ultimately impact two important dimension of performance in software development projects: team ability to deliver software on time and team ability to deliver software with the expected quality (Damian and Zowghi 2003; Faraj and Sproull 2000).

Given the challenges created by national diversity to global software development teams, it is important to identify mechanisms that facilitate the integration of knowledge in such multicultural work environments (Dibbern et al. 2008; Espinosa et al. 2007). Research on global software development teams is especially relevant today, when the software industry has shifted from an on-site onshore approach to an outsourced offshore approach. As a result, organizations are relying more on global teams for the development and maintenance of their IS/IT infrastructure (Dibbern et al. 2008). Furthermore, the offshore software development market is expected to represent one quarter of US and European spending on software application development, integration, and management services in the short term (Conchuir et al. 2009).

Literature suggests that differences among members of global teams become less detrimental to team effectiveness when team members are aware of their differences and develop work practices to navigate around them (Earley and Mosakowski 2000; Munkvold and Zigurs 2007). However, studies also indicate that developing such cultural awareness takes time (Earley and Mosakowski 2000).

Drawing on these two premises, this paper proposes that global software development teams comprised of individuals who have worked together in the past are more likely to succeed over newly formed teams because the former are better prepared to deal with their differences. The argument is that when individuals who have worked together in the past (i.e., who have previous working ties) are teamed up again in a new project, they will capitalize on the experiences and work practices that led to prior effective collaboration, and will apply the lessons learned in the service of the new project (Watson-Manheim et al. 2012).

Literature already highlights the positive impact that previous working ties have on software teams (Espinosa et al. 2007; Huckman et al. 2009). This paper draws on information processing theory (Hinsz et al. 1997) to add to this body of literature by suggesting that previous working ties have a direct impact on software quality and development speed as well as an indirect effect by ameliorating the negative impact that national diversity may have on software quality and development speed.

2 Theoretical Background

Information processing theory examines how teams integrate ideas, perspectives, and other cognitive resources (Hinsz et al. 1997). Information processing involves the consideration of alternative sources of knowledge, represented as team members' perceptions and views, and the convergence of those different mental models into a common framework (Carton and Cummings 2012). Team information processing is critical for success, given that individuals working on teams usually need to share information to effectively coordinate their activities (Hinsz et al. 1997).

Information processing theory indicates that teams responsible for cognitively demanding tasks, such as software development, are effective to the extent that members are able to: (1) exchange information and perspectives; (2) engage in individual-level processing of the shared information and perspectives; (3) provide feedback on the results of individual-level processing to the group; and (4) discuss and integrate each other's views (Hinsz et al. 1997; van Knippenberg et al. 2004). Therefore, a key element for effective team information processing is the possibility of exchange and integration of information.

Information processing theory has three main lines of research examining the elements influencing the effective exchange and integration of information among team members: (1) diversity theory (van Knippenberg et al. 2004); (2) information-exchange theory (Stasser et al. 1995); and (3) transactive memory systems theory (Wegner 1986). These three perspectives serve as our theoretical foundation to explain the role of previous working ties in global software development teams.

2.1 Diversity Theory

According to the team literature, having access to a variety of information and perspectives enhances a team's capabilities of accomplishing its goals (Rico et al. 2008). Thus, a team comprised of members from different backgrounds has access to a wider range of perspectives, values, and information. In this case, teams benefit from the different and complementary skills each member brings to the group (Bunderson 2003). Having peers with different views also helps team members approach problems from various angles (Carton and Cummings 2012), improves brainstorming, and facilitates the discussion and integration of new work practices (van Ginkel and van Knippenberg 2009).

However, diversity can also be detrimental to the exchange and integration of information. The convergence of mental models among individuals holding different views and perspectives of the world is difficult because they do not share a common framework to facilitate mutual understanding (Carton and Cummings 2012). In that case, individuals may perceive the team's tasks, processes and objectives differently, leading to gaps between teammates' interpretations of what needs to be done and potentially leading to conflict and coordination problems (Cronin and Weingart 2007; Pelled et al. 1999).

2.2 Information-Exchange Theory

Information-exchange theory indicates that group interaction constitutes the means by which ideas and resources are exchanged within a team (Stasser et al. 1995). Thus, the better the quality of those interactions, the easier it will be for team members to integrate their knowledge (Stasser et al. 1995). A core assumption of the theory is that information exchange improves when individuals have a common channel to transmit information (Shannon et al. 1949). In that case, the process of coding and decoding messages becomes less costly. Developing a shared and stable communication framework allows the sender and receiver to communicate accurately (Shannon et al. 1949), reducing uncertainty and errors during the information exchange process (Lawrence and Lorsch 1986). At the team level, having a common communication channel includes relying on established processes and predefined work practices for group interactions (Cramton 2001).

2.3 Transactive Memory System Theory

Finally, transactive memory system theory indicates that information processing at the group level is more effective when members are aware of how knowledge is distributed

across the team (Wegner 1986). The creation of knowledge directories allows teams to improve information allocation and retrieval, and reduces the chances of members struggling to acquire information that is already available to the team (Kanawattanachai and Yoo 2007; Lewis 2003). As a result, team members are able to better match members' knowledge to a task, exchange information faster, and specialize in different but compatible knowledge domains while relying on each other for collaboration (Keskin 2009).

2.4 The Role of Previous Working Ties

Previous working ties capture the collaboration that existed among team members before the formation of their current team (Parise and Rollag 2010). Multiple studies in the field of diversity (Earley and Mosakowski 2000; Lewis 2003; Watson et al. 1993), information exchange (Cramton 2001; Gardner et al. 2012) and transactive memory systems (Kanawattanachai and Yoo 2007; Lewis 2003) indicate that integration and exchange of information among team members improves as they gain experience working together.

Literature on team diversity suggests that as individuals with different backgrounds work together, they increase their mutual understanding and are able to predict behavior and match expectations previously perceived as inconsistent (Watson et al. 1993). Thus, the negative effects of diversity on team processes, states, and outcomes are reduced when individuals with different backgrounds interact over an extended period (Watson et al. 1993). For example, Harrison et al. (1998, 2002) found that the negative effects of diversity based on age, sex, ethnicity, and marital status on team performance weaken as members spend time working together.

Research in the field of information exchange also suggests that individuals who work together over a long period of time tend to gain a better understanding of each other's communication processes and preferences, improving their information exchange capabilities (Warkentin and Beranek 1999). Similarly, individuals working together tend to develop their own vocabulary and symbols (Earley and Mosakowski 2000), which facilitates information exchange (Gardner et al. 2012). Finally, with experience individuals learn more about one another's areas of expertise and can validate such expertise (Lewis 2003), which allows team members to be more effective when seeking information among fellow team members (Lewis and Herndon 2011; Ren and Argote 2011).

3 Hypotheses

3.1 National Diversity

Knowledge combination is difficult to achieve among individuals from different countries (Hofstede 1983; Walsham 2002). Variations in cognitive structures among individuals from different nationalities may result in incongruent and unexpected behavior, preventing the convergence of mental models among members of global teams (Carton and Cummings 2012). Likewise, differences in native languages can create barriers to the sharing and conversion of declarative and procedural knowledge (Baba et al. 2004) because individuals from different countries may not share the same medium (e.g., language) to transmit information. This could also increase complexity in communication processes and the rate of errors during the exchange and integration of information among members of global teams (Maznevski and Chudoba 2000).

Literature indicates that the combination of team members' creativity, technical expertise, and experience plays an important role in the quality of any software to be implemented (Faraj and Sproull 2000; Kotlarsky et al. 2008; Oshri et al. 2008). As national diversity imposes barriers to the proper exchange and integration of information, the quality of the software developed by a global team may be affected. Supporting this view, Gibson and Gibbs (2006) found that national diversity represented as differences in ideas about teamwork, values, and work hierarchy hindered innovation in global teams. Similarly, Kayworth and Leidner (2002) observed that linguistic differences among members of global teams led to information loss and distortion during communication episodes, affecting their task performance.

Hypothesis 1a In global software development teams, national diversity is negatively associated with software quality.

Despite the challenges created by national diversity, members of global teams are expected to be able to exchange and integrate information. To do so, they need to develop work practices and communication schemas that allow them to overcome the information-processing problems arising from their cultural, social, and idiomatic differences. This may include having longer interactions to clarify thoughts, spending more time defining internal structures for dispute resolution, or discussing the best ways to communicate ideas and task-related information (Earley and Mosakowski 2000).

Therefore, when members of global software development teams try to integrate their knowledge, they might spend considerable time solving communication breakdowns and addressing cultural differences rather than performing task-related activities (Elron 1997; Von Glinow et al. 2004), which could affect a team's ability to develop the product on time. Supporting this view, Shachaf (2008) found that members of global software development teams invest more time and effort coding and decoding messages when communicating with someone from a different

culture. Similarly, Earley and Mosakowski (2000) found that in multicultural teams, members expend considerable time communicating and trying to understand each other before reaching consensus on how to execute their tasks.

Hypothesis 1b In global software development teams, national diversity is negatively associated with software development speed.

3.2 Previous Working Ties

A history of working together in the past enables team members to build up cumulative experiences to enhance their knowledge integration capabilities (Vashdi et al. 2012). By working together individuals learn about each other's knowledge, skills, and abilities (KSAs), and start developing mental models to represent such information (Alavi and Leidner 2001; Lewis 2003). The development of such mental models leads to better team expertise location and task-knowledge coordination (Kanawattanachai and Yoo 2007; Lewis 2003). This facilitates knowledge integration among team members (Brandon and Hollingshead 2004; Wegner 1986). In this sense, previous working ties can be especially beneficial in global software development teams, given that knowledge location and information integration are necessary tasks for the success of any software development endeavor (Damian and Zowghi 2003; Faraj and Sproull 2000) but are difficult to achieve in a distributed work environment (Cummings et al. 2009; Massey et al. 2003). Literature provides support for the positive effect that previous working ties may have on software development quality. For example, studies found that previous working ties increase the likelihood of completing error-free software modification requests (Espinosa et al. 2007) and reduce the likelihood of post-delivery flaws (Huckman et al. 2009).

One could argue that previous working ties could be detrimental to team effectiveness if teams are composed of individuals with interpersonal problems from previous projects. However, literature suggests that in long professional relationships, like the ones created while working together on different projects, teams are more likely to solve their conflicts in a constructive manner in order to maintain harmony in their workplaces (Curşeu and Schruijer 2010; Paul and McDaniel 2004; Peterson and Behfar 2003). Similarly, with repeated experience working together on different projects, individuals enhance their ability to detect interpersonal conflict among members and are more willing to use peer pressure to assert corrective actions (Edmondson 1999; Kandel and Lazear 1992).

Previous research has provided evidence of the impact of time spent working together on team effectiveness. For example, Ayoko (2012) found that newly formed groups tended to experience high levels of interpersonal conflict and attacks. However, as individuals spent time working together, they realized that such conflict hindered team performance, and started to develop their own conflict–resolution mechanisms. Similarly, Price et al. (2006) found that time working together was a significant predictor of team members' ability to identify free-riders, and to exert peer pressure to limit free-riding.

Overall, these results support the idea that as individuals spend time collaborating across different projects, the team as a work unit is more likely to improve its information processing capabilities, as well as to develop mechanisms to overcome previous negative experiences.

Hypothesis 2a In global software development teams, previous working ties are positively associated with software quality.

Similarly, when team members have worked together in the past they are aware of "who knows what" within the team. This increase of mutual knowledge reduces the transaction cost associated with information sharing and knowledge coordination (Boh et al. 2007; Harrison et al. 2002; Reagans et al. 2005). The team becomes more efficient in the execution of its tasks because members expend less time trying to understand how and where knowledge is distributed across the team (Faraj and Sproull 2000; Lewis 2003). Thus, as members of global software development teams gain experience working together, expertise location and task-knowledge coordination are less time-consuming, improving the development speed of the team. Supporting these views, studies have found that teams comprised of individuals who have worked together in the past tend to have shorter task completion times than newly formed groups (Harrison et al. 2002; Reagans et al. 2005).

Hypothesis 2b In global software development teams, previous working are positively associated with software development speed.

3.3 The Moderation Role of Previous Working Ties

National diversity is detrimental to global software development teams because members from different countries have varying representations of the world, and such representational gaps can prevent exchange and integration of information, affecting the team's ability to develop software on time and with the expected degree of quality.

According to information processing theory, the development of shared understanding among participants is central to bridging such representational gaps, so that team members can interpret and translate each other's knowledge (Cronin and Weingart 2007). As members of global software development teams gain experience working

together, they could increase mutual understanding of one another's cultural preferences and values (Harrison et al. 2002; Watson et al. 1993). For example, Mortensen and Neeley (2012) found that when individuals spent time working with peers, they gained knowledge about their personal characteristics, expectations, and behavioral norms. Similarly, as members of multicultural teams increase their levels of cultural awareness through different interactions, they are more likely to develop better conflict management mechanisms, reducing the likelihood that their cultural differences might lead to breakdowns in processes (Earley and Mosakowski 2000). For example, Pelled et al. (1999) found that as group longevity increased, age, tenure and educational diversity were less likely to foster task and process conflict.

Thus, as members of global software development teams gain experience working together on multiple projects, they may become more conscious of each other's cultural differences, and be better prepared to work together as a diverse team. Exchange and integration of information among individuals from different countries improves, reducing the chances that differences among members from dissimilar countries may lead to software defects.

Hypothesis 3a In global software development teams, previous working ties moderate the negative relationship between national diversity and software quality, such that the relationship is weaker for teams with high levels of previous working ties.

Similarly, mutual understanding of others' cultural preferences and values through previous working ties may also result in more efficient communication processes among members from different countries. For example, Earley and Mosakowski (2000) found that members of multicultural teams resolved their disagreements faster and made decisions more quickly as they spent time working together. In this case, previous working ties served as a mechanism to help members from different countries collaborate and integrate their knowledge faster.

Hypothesis 3b In global software development teams, previous working ties moderate the negative relationship between national diversity and software development speed, such that the relationship is weaker for teams with high levels of previous working ties.

4 Method

4.1 Settings

This study is based on data collected from Global InfoCom (pseudonym), a global software development company focused on the telecommunications industry. The company has over 250 employees across offices in Europe, the Middle East, and Central and South America. The main development team is located in Denmark, and the main testing team is located in France. Local offices (e.g., Middle East, Central and South America) have groups of engineers to provide basic customer support. However, if a major issue arises, support from Demark and France is required. Project managers and engineers are assigned to projects depending on availability and technical needs. Team members, project managers, and engineers typically have weekly update meetings.

4.2 Sample and Measures

The initial sample included 79 global software development teams. We excluded 17 teams due to missing data, leaving a final sample of 62 teams. Members of those teams were located across five different countries: Mexico, Colombia, Brazil, France, and Denmark. For this study, all the key variables are based on objective measures.

4.2.1 Software Quality and Software Development Speed

The number of unsuccessful test cases reported by the customer during the customer-acceptance test phase was used to represent quality of the software (Gopal and Gosain 2010). Development speed was calculated based on the number of days from the date that the client signed the kick-off meeting to the date that the client signed the acceptance of the software. We obtained this information from the company's project management system. As recommended by the literature (Krishnan et al. 2000), we normalized our measures according to software size (1,000 lines of code) to allow comparison across projects. Thus, the measure of software development speed represents 1,000 lines of code coded per day. The measure of software quality represents 1,000 lines of code per defects. A Q–Q plot analysis indicated that both measures were skewed to the left. A natural logarithm transformation gave the best approximation to a normal distribution.

4.2.2 National Diversity

The company's human resources department provided employees' demographic information. National diversity was calculated using Blau's (1977) index of heterogeneity, which is the recommended index to use when measuring diversity as an indicator of variety among team members (Harrison and Klein 2007). The index was calculated as follows: $D = 1-\Sigma(P_i^2)$, where P represents the proportion of team members from a specific nationality, and i is the number of nationalities represented on the team.

4.2.3 Previous Working Ties

Archival data from the host company was used to identify the projects on which members had worked together for the last 2 years before the formation of their current team as well as the duration of those projects. Following the literature (Reagans et al. 2005), previous working ties were computed as: $(\Sigma i\ \Sigma j\ (d_{ij}))/(N(N-1)/2)$, where d_{ij} is the number of days that members $_i$ and $_j$ had worked with each other during the two-year period before the project started and $(N(N-1)/2)$ represents the possible number of member pairs available to that team. Potential values range from zero, if there were no previous working ties among any team members, to one, if all members on the team had continuously worked together for the two-year period before their current project started.

4.2.4 Control Variables

This study controlled for team size because larger teams usually reflect a better distribution of skills, which tends to improve software quality (Banker et al. 1998). Team dispersion was also included as a control variable because of the possibility that some of the negative effects of national diversity may be caused by having members located in different sites. Dispersion among team members was measured using the index defined by O'Leary and Cummings (2007). This index includes physical distance, number of locations, temporal dispersion, members' isolation, and imbalanced distributions of team members across locations. Finally, task and relational conflict were also included as control variables, given that negative interpersonal relationships among team members could affect a team's ability to develop software on time and with the expected quality. Relationship and task conflict were collected at the end of each project using the intragroup conflict scale (Jehn 1995). The Cronbach's alpha scores for the scales of relationship and task conflict were 0.92 and 0.83, respectively. Individual values of relationship and task conflict were aggregated to form team-level scores.

4.3 Analysis and Results

Hypotheses were tested using hierarchical regression analysis (Cohen 2003). Predictors were z-standardized to have a sample mean of 0.0 and a standard deviation of 1.0. The interaction term was computed using the z-standardized scores of the predictors. The first regression model evaluated the effect of the control variables on software quality and development speed. The second model included the measures of national diversity and previous working ties. The third model included the interaction term between national diversity and previous working ties. Descriptive statistics and correlations among the study variables are presented in Table 1. The research model and the results of the regression analysis are presented in Fig. 1 and Table 2.

In relation to the control variables, Table 1 indicates a negative correlation between previous working ties and task and interpersonal conflict. Similarly, Table 2 indicates that task and interpersonal conflict were negatively related to software quality and speed; however, the relationship became non-significant when the measure of previous working ties was introduced in the regression analysis. A post hoc regression analysis indicated that previous working ties were negatively related to task conflict ($\beta = -0.32$, $\rho < 0.001$) and interpersonal conflict ($\beta = 0.37$, $\rho < 0.001$). These results support the idea that previous working ties are likely to positively impact software quality and development speed despite the presence of task and relational conflict among team members. In relation to the hypotheses, national diversity had a significant negative impact on software quality and development speed, supporting Hypotheses 1a and 1b.

Previous working ties had a significant positive effect on software quality and development speed, supporting Hypotheses 2a and 2b. Finally, the interaction between

Table 1 Descriptive statistics and correlations among the study variables

Variable	Mean	SD	1	2	3	4	5	6	7
1. Team size	7.73	2.46							
2. Team dispersion	3.99	0.44	−0.16						
3. Task conflict	3.45	0.13	0.21	0.27*					
4. Relational conflict	2.76	0.35	0.18	0.25	0.31*				
5. National diversity	0.46	0.25	−0.01	0.03	0.37**	0.28*			
6. Previous working ties	0.42	0.39	−0.15	0.01	0.33**	−0.04**	0.12		
7. Quality of the product	2.45	1.12	−0.01	0.16	-0.34**	0.28*	−0.34**	0.28*	
8. Duration of development cycle	1.22	0.51	−0.19	−0.38**	−0.26*	0.15	0.07	0.15	0.07

* $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$

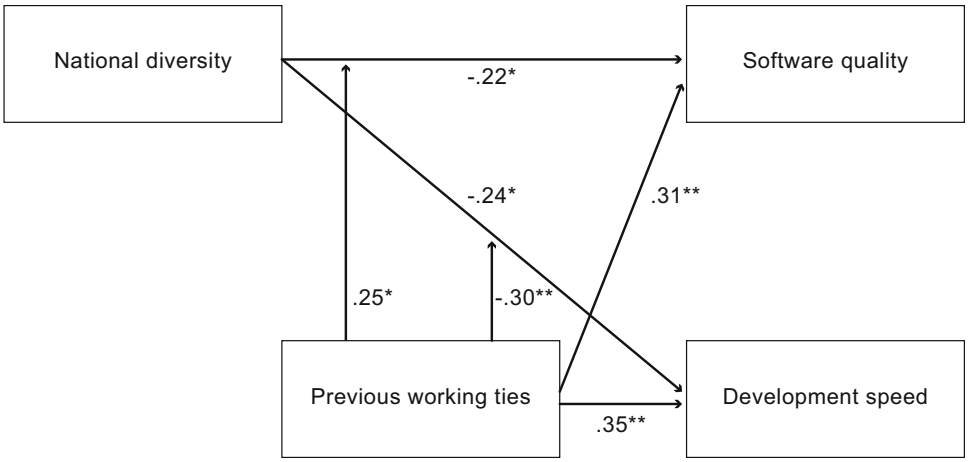

Fig. 1 Research model with resulting regression coefficients $*p < 0.05$, $**p < 0.01$ and $***p < 0.001$

Table 2 Results of regression analysis

Variable	Model 1: software quality			Model 2: development speed		
	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Team size	0.26*	0.25*	0.25*	0.32**	0.33**	0.31**
Team dispersion	−0.19	−0.07	−0.03	−0.23*	−0.23*	−0.23*
Task conflict	0.31*	−0.12	−0.12*	−0.27*	−0.11	−0.11
Relational conflict	−0.27*	−0.15	−0.13	−0.33**	−0.12	−0.12
National diversity		−0.25*	−0.22*		−0.26*	−0.24*
Previous working ties		0.33**	0.31**		0.36**	0.35**
National diversity × Previous working ties			0.25*			−0.30**
Model						
R^2	0.10	0.27	0.45	0.16	0.34	0.49
ΔR^2	0.10	0.16*	0.18**	0.16*	0.19**	0.21***
F	2.05	2.71	4.03*	2.58*	1.20	4.35***

* $p < 0.05$ ** $p < 0.01$ and *** $p < 0.001$

national diversity and previous working ties was significant and explained an additional variance in software quality and development speed after controlling for all other predictors. Figures 2 and 3 provide a graphical depiction of the simple slope analysis as suggested by Holmbeck (2002). Figure 2 indicates that the relationship between national diversity and software quality was negative in teams that lacked previous working ties, but positive when previous working ties were high. Figure 3 indicates that the effect of national diversity on development speed was still negative, but less pronounced in teams that scored high on the measure of previous working ties. These results support hypotheses 3a and 3b.

5 Discussion and Implications

This paper drew on information processing theory (Hinsz et al. 1997) to propose that national diversity creates barriers to the exchange and integration of information among members of global software development teams and that previous working ties can serve as a mechanism to facilitate exchange and integration of information in those teams. Based on these two ideas, this study hypothesized that the negative effect of national diversity on software quality and development speed is influenced by the amount of time that team members have spent working together in the past. Our findings support this view.

Teams composed by members with high levels of previous working ties developed software of higher quality and at a faster pace. These results are aligned with previous studies examining the influence of working ties on task quality and completion time. For example, Espinosa et al. (2007) found that previous working ties among global software development teams reduced the time required to complete error-free modifications. Similarly, Reagans et al. (2005) found that previous working ties reduced completion time in surgical teams performing joint replacement procedures.

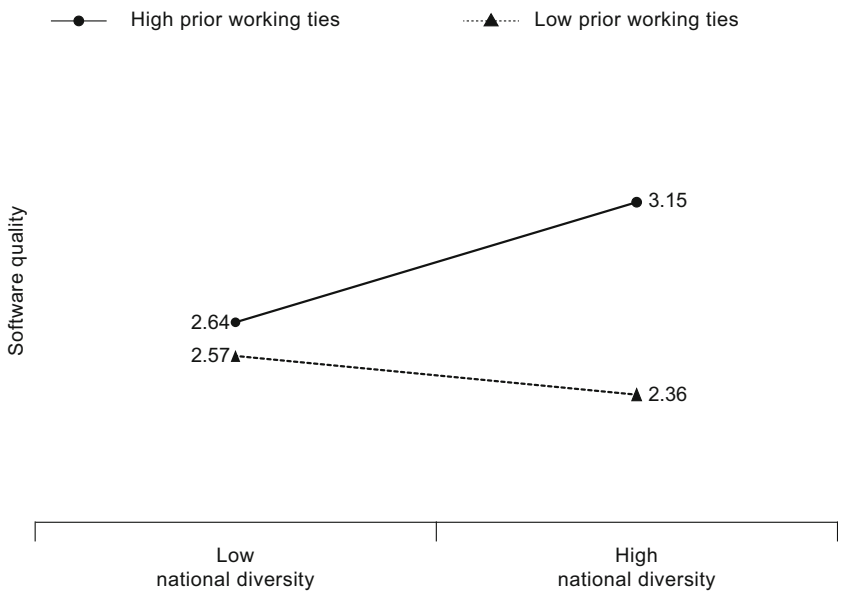

Fig. 2 Previous working ties as a moderator of the relationship between national diversity and software quality

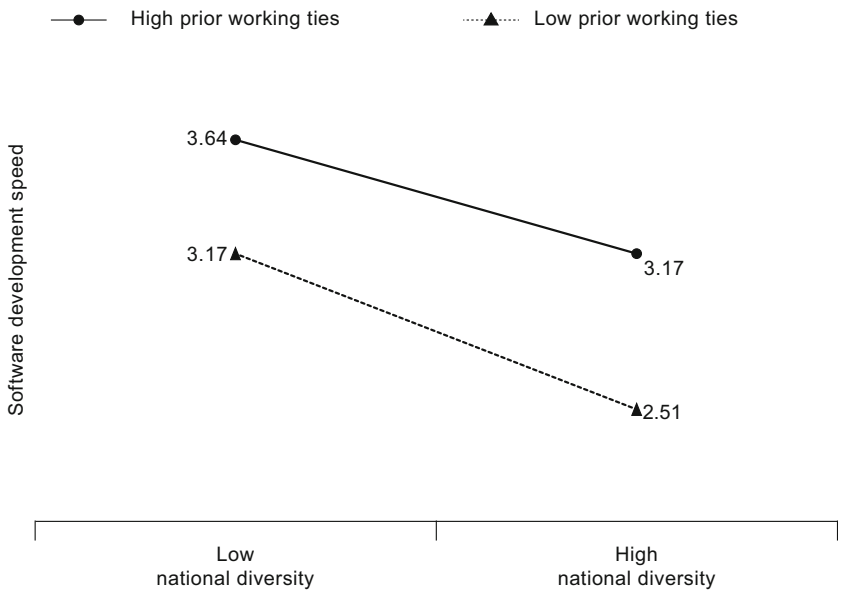

Fig. 3 Previous working ties as a moderator of the relationship between national diversity and software development speed

Related to global software development teams, these findings suggest that the experience members gain by working together across different projects serves as a basis for better knowledge coordination and helps the team overcome some of the process losses inherent to information exchange among members from different countries (Cramton 2001; Maznevski and Chudoba 2000). To substantiate these assumptions, further research should examine team processes such as information exchange, team coordination, or even the development of transactive memory systems to better understand the impact that previous working ties have on global teams.

An interesting finding in this study is that previous working ties not only influenced the strength of the relationship between national diversity and software quality, but also the direction of this relationship. National diversity was detrimental to software quality in teams with low levels of previous working ties; however, national diversity led to better software quality in teams with high levels of previous working ties (Fig. 2). This finding indicates that under certain conditions national diversity can have a positive impact on team effectiveness. Previous studies have also found that global teams can capitalize on the multicultural nature of their members (Shachaf 2008). Nevertheless, there is still a lack of clarity about under which conditions national or even cultural diversity can positively influence global teams' processes, states, and outcomes (Paul and McDaniel 2004; Watson-Manheim

et al. 2012). This study found that one way to take advantage of such diversity is by creating global teams with individuals who have worked together in the past. Such a work practice can allow global software development teams to capitalize on their ability to bring together expertise from around the globe, while at the same time reducing the coordination and communication problems associated with having a multinational and multicultural work force.

In relation to the current literature, most of the studies that examine national diversity in global software development teams have taken a cross-sectional approach without accounting for the possibility that the effect of diversity on global teams may evolve over time (Gibson and Gibbs 2006; Hinds and Mortensen 2005; Paul and McDaniel 2004). However, this study found that the relationship between national diversity and software quality and development speed changed as members gained experience working together through different projects. This suggests that the effects of national diversity on team processes, states, and outcomes could vary at different stages of the software development process. Thus, there is need for more research about national diversity on global teams that accounts for time-based processes such as the ones presented in Baba et al. (2004), Kankanhalli et al. (2007) or Bjørn and Ngwenyama (2009). Such research will provide a more dynamic perspective on how interactions among members of global teams evolve over time.

Another important finding from this study was that previous working ties had a stronger positive effect in highly diverse teams compared with more homogeneous teams. When previous working ties among team members were high, software quality was significantly better among teams that had greater national diversity (Fig. 2). Similarly, the improvement in development speed due to previous working ties was stronger among highly diverse teams, compared to less diverse teams (Fig. 3).

A possible explanation for these findings could be that exchange and combination of information in homogenous teams is easier than in more diverse teams (O'Reilly et al. 1989; Pelled et al. 1999). Thus, the effect of any intervening mechanism that facilitates information processing, such as the experiences gained through previous working ties, would be more beneficial in conditions where information processing is harder to achieve, which is the case for teams high in national diversity. This is aligned with the view that intervening mechanisms are more effective in contexts where they are needed. For example, Espinosa et al. (2007) found that previous working ties had a stronger influence on performance in global software development teams than in collocated teams because the benefits of these ties (i.e., better expertise location, greater mutual understanding, and improved inter-team communication) were more important to distributed teams than to collocated teams. Similarly, under the assumption that learning about others' cultures is critical to the exchange of information in multicultural teams, Pieterse et al. (2012) found that team members' learning orientations had a stronger positive effect on performance in culturally diverse teams than in homogeneous teams. Thus, the results from this study suggest that the effectiveness of previous working ties on global teams may depend on team characteristics, such the degree of team diversity.

5.1 Theoretical and Practical Contributions

Most of the theories related to diversity on global teams usually examine the topic from a social identity perspective (Tajfel 1982), which proposes that diversity is detrimental to team processes and outcomes because it reduces social integration and creates division within the team. Thus, theoretical literature tends to propose that national diversity is detrimental to global team effectiveness (Fiol and O'Connor 2005; Hinds and Bailey 2003; Kankanhalli et al. 2007; Maznevski and Chudoba 2000). However, empirical studies have not always supported this view. Some studies have found the relationship between national diversity and team effectiveness to be positive, while in others the relationship was negative or not significant (Cousins et al. 2007; Paul and McDaniel 2004). Such mixed findings suggest the presence of boundary conditions that influence whether the impact of national diversity on team effectiveness is negative or positive (Watson-Manheim et al. 2012). However, a social identity theory perspective would not be able to explain these boundary conditions given that the theory does not account for the possibility that diversity can enhance team effectiveness (Tajfel 1982).

To address this caveat, this paper drew on information processing theory (Hinsz et al. 1997), which suggests that whether diversity is beneficial or detrimental to team effectiveness is contingent on the presence of mechanisms that facilitate or hinder team members' ability to integrate their different perspectives. Findings from this study support the information processing theory view: national diversity was detrimental to software quality at low levels of previous working ties, but beneficial at high levels of previous working ties.

Based on this finding, this study proposes that the level of previous working ties among team members is an important boundary condition when understanding the relationship between national diversity and different measures of performance (e.g., software quality and development speed). Theorizing and identifying boundary conditions is essential because it allows the research community to specify more robust models with higher explanatory power. The specification of boundary conditions could also help

clarify why previous research indicated mixed results regarding the effects of national diversity on global team effectiveness (Watson-Manheim et al. 2012).

As for practical implications, the results of this study provide guidance regarding personnel selection for global software development teams. Although it is important for managers to evaluate the technical skills and work experience of each team member, they should also consider the level of experience the team as a whole has working together in the past. Team leaders may select the best and the brightest employees expecting to create successful global software development teams; however, if these individuals are complete strangers, they will spend a considerable amount of time trying to overcome communication and process breakdowns due to their cultural and social differences instead of doing their jobs. Thus, managers should encourage the formation of global software development teams composed of individuals who have worked together in the past. This would improve the chances of success for their teams by taking advantage of the time, effort, and resources those individuals have spent overcoming their cultural and social differences in previous projects.

5.2 Limitations and Conclusion

The following selection discusses theoretical and methodological limitations of this study, along with recommendations for future research. First, this study proposed that forming teams with individuals who have previous working ties improves software quality and development speed regardless of the quality of those relationships. However, it is possible that a newly-formed team could perform better than a team composed of members who have experienced an unproductive or conflictive work relationship in the past (Liden et al. 2000). Although this study did not directly measure the quality of the relationship among team members, it did control for task and relational conflict. Results indicated that previous working ties had a positive effect on software quality and speed, even after accounting for the effects of task and interpersonal conflict. These findings provide some support for the idea that prior working ties improve team effectiveness regardless of the quality of the interpersonal relationships among team members. However, future research on this topic should be aware that the quality of the relationships between team members could influence how previous working ties affect team effectiveness.

Another limitation of this study is that it examined the direct relationship between national diversity, software quality, and software development speed. Future research could include mediator variables (such as team cohesion, use of information, and collaboration) to better explain the impact of national diversity on global software development teams.

Despite these limitations, this study used objective measures for all the key variables and used two independent constructs (software quality and development speed) to measure team performance. The fact that national diversity and previous working ties had similar effects on both dimensions of performance improves the reliability of these findings. Although studies in the organizational behavior literature have already examined how the impact of diversity on team effectiveness changes as members interact with each other (Harrison et al. 2002; Pelled et al. 1999; Watson et al. 1993), those studies took place in collocated environments. Our findings extend this line of research to a distributed global environment and suggest that the benefits of previous working ties can also materialize in a work context characterized by limited social and face-to-face interactions among participants (Cramton 2001).

Finally, using objective measures of team performance also allowed us to overcome the limitation of using perceptual measures of performance, which usually are biased. Overall, the findings of this study suggest that greater attention needs to be paid to the mechanisms that facilitate and hinder knowledge integration among members of global software development teams as well the impact of national diversity on various team outcomes.

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