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Fostering ambidextrous innovation in infrastructure projects: differentiation and integration tactics of cross-functional teams

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Abstract： In infrastructure project practice, balancing and maximizing the combined effect of exploratory and exploitative innovation have attracted increasing attention, but it is still unclear how to foster ambidextrous innovation in infrastructure projects. To address this gap, we draw on the "differentiation–integration" framework of ambidexterity theory to deconstruct tactics for fostering ambidextrous innovation in infrastructure projects. A total of 313 observations were collected from infrastructure under construction, and the path hypotheses were tested by hierarchical regression. The findings suggest that in infrastructure projects, task conflict and expertise integration of diverse cross-functional teams provide powerful and complementary tactics for fostering ambidextrous innovation. The moderating effect of team autonomy support on the impact of team diversity on differentiation and integration tactics presents three different results. This study not only enriches the literature on how to

foster ambidextrous innovation in infrastructure projects, but also expands the ambidexterity research at the cross-functional team level and in infrastructure project contexts.

Keywords: Ambidextrous innovation; Cross-functional team; Team diversity; Task conflict; Expertise integration; Team autonomy support

Introduction

Those using innovative practices in infrastructure projects often face a dilemma. To reduce uncertainty and the risk of cost and schedule overruns, owners are inclined to choose exploitative innovations, such as simple improvements to tested techniques and established routines (Davies et al. 2014; van Marrewijk et al. 2008). However, the uniqueness and complexity of infrastructure projects necessitate exploratory innovations that involve the development of new technologies and the adoption of new processes (Beliz and Kutluhan 2017; Christian et al. 2016). Therefore, both exploitative and exploratory innovations merit consideration in infrastructure projects. While excessive attention to exploitative innovation can lead to a short-term “success trap” and fail to achieve long-term success (Gupta et al. 2006), excessive attention to exploratory innovation can lead to endless “failure cycles” (Petro et al. 2019). In summary, both exploitative and exploratory innovation are needed in infrastructure projects, without either being ignored or over-used. As such, care must be taken in infrastructure practices to balance these two innovation types and maximize their combined effects, which is a concept known as ambidextrous innovation (Andriopoulos and Lewis 2009).

Whereas many studies of infrastructure innovation have focused on one or another exploratory or exploitative innovation (e.g., Turnheim and Geels (2019) and van den Hoogen and Meijer (2015) focused on exploratory innovation; Brooks et al. (2011) and Gil and Beckman (2007) focused on exploitative innovation), far less attention has been given to the simultaneous use of exploratory and exploitative innovations. In addition, many studies have reported that projects provide the best context for contextualizing ambidextrous innovation (Petro et al. 2019; Turner et al. 2014, 2015), yet the study of most ambidextrous innovation projects have been based on product design projects (e.g., Andriopoulos and Lewis 2009), manufacturing projects (e.g., He and Wong 2004) and IT projects (e.g., Turner et al. 2016). As noted above, ambidextrous innovation is critical in in infrastructure project practice, but there is scant research on ambidextrous innovation in infrastructure projects. Several scholars have emphasized the importance of ambidextrous innovation in infrastructure projects (e.g., Wang et al. 2009) and its positive impact on infrastructure project performance (Liu and Leitner 2012). However, very little is known about how to foster ambidextrous innovation in infrastructure projects, a gap crisply summarized by Liu and Leitner (2012), who claimed that few studies have examined how ambidextrous innovation can be achieved in infrastructure projects.

To address this gap, we draw on the "differentiation–integration" framework of ambidexterity theory to deconstruct tactics for fostering ambidextrous innovation in infrastructure projects. Ambidexterity theory suggests that the differentiation and integration of diverse teams provide powerful and complementary tactics for fostering ambidexterity (Andriopoulos and Lewis 2009; Jansen et al. 2009). Whereas team diversity helps to identify multiple inconsistencies and conflicts, exploratory and exploitative innovations must be differentiated, coordinated, integrated, and applied (Jansen et al. 2009). On this basis, here, we examine how differentiation and integration mediate the relationship between team diversity and ambidextrous innovation in infrastructure projects.

Specifically, we take cross-functional teams as the research object. Many scholars have emphasized the critical role of cross-functional teams in fostering ambidextrous innovation (Jansen et al. 2009; Strese et al. 2016), but more importantly, they have stated that cross-functional teams play a vital role in infrastructure projects. Cross-functional teams are the central aspect of the infrastructure project network (Love and Roper 2009). These teams connect high-level decision-making with low-level implementation, and promote interaction between different functional departments (Laurent and Leicht 2019). In this study, we apply the "differentiation–integration" framework to the infrastructure project context. As cross-functional team members represent different functional departments, they have different understandings of the project task assignments and the prioritization of project goals, which can trigger task conflicts (Wu et al. 2020). In addition, expertise from different departments must be integrated to gain a comprehensive understanding at the cross-functional team level, and a more comprehensive knowledge base for ambidextrous innovation (Sheng et al. 2018). This study also differs from previous research based on the "differentiation–integration" framework, which has generally been validated at the top management team level (e.g., Jansen et al. 2009). Since cross-functional teams are middle-level entities in infrastructure projects, the impact of the team member diversity on its differentiation and integration tactics may be affected by the degree of autonomy accorded its members (Rico et al. 2007). Fig. 1 shows the research model we established for this study.

(Please insert Fig.1 here)

This study enriches the literature on how to foster ambidextrous innovation in infrastructure projects. Specifically, we validate the "differentiation–integration" framework within the ambidexterity theory from the perspective of the cross-functional teams in infrastructure projects, which extends the existing theory of project ambidexterity, and provides a novel interpretation of the role of cross-functional teams in fostering ambidexterity. The results of this study also provide insights into infrastructure practices that executives and cross-functional teams can use to develop tactics and avenues for fostering ambidextrous innovation.

Literature Review and Hypotheses

Team Diversity and Ambidextrous Innovation

Ambidexterity theory suggests that the differentiation and integration of diverse teams provide powerful and complementary tactics for fostering ambidexterity (Andriopoulos and Lewis 2009; Jansen et al. 2009). Because a diverse team has more discussions and knowledge collisions before reaching consensus, and better integrates different expertise and viewpoints from various departments (Kearney et al. 2009), thus it can make more comprehensive, rational, and creative decisions than homogeneous teams (Stewart 2006), and can better achieve ambidextrous innovation (Junni et al. 2015). In infrastructure project practice, the cross-functional teams are often diverse teams, and the team members have different work experience, professional background, and educational level (Sheng et al. 2018). In particular, the cross-functional team members of infrastructure projects are often leaders of different functional departments, so that the cross-functional team can coordinate cross-functional work (Li et al. 2018), thereby facilitating infrastructure projects achieve ambidextrous innovation (Liu and Leitner 2012). Therefore, the following hypothesis is developed.

Hypothesis 1: In infrastructure projects, cross-functional team diversity has a positive impact on ambidextrous innovation.

Mediating Role of Task Conflict

In the "differentiation-integration" framework, both differentiation and integration are core elements in the ability to pursue exploratory and exploitative activities simultaneously (Jansen et al. 2009), and conflict can be a good representation of differentiation (Andriopoulos and Lewis 2009). Team conflict is generally divided into task conflict and relationship conflict (Jehn et al. 2008). Task conflict emphasizes the expression of differences in perspectives directly related to the team task (Jehn 1995; Jehn et al. 2008), and it typically refers to disagreements among team members about the content of decisions in the collective decision-making process (Simons and Peterson 2000). While, relationship conflict, also known as affective or interpersonal conflict, is characterized by tension, suspicion, friction and distrust (Simons and Peterson 2000). Existing studies have confirmed the positive impact of task conflict on team performance, ambidexterity and innovation (De Dreu 2006; Martin et al. 2019), while the impact of relationship conflict on team outcomes tends to be negative (Simons and Peterson 2000; Tjosvold et al. 2014). Therefore, if we consider "conflict" in general and do not distinguish the types of conflicts, the impact of these two conflicts may be offset, more importantly, compared with relationship conflict, task conflict can better characterize the "differentiation" in the process of cross-functional teams pursuing ambidextrous innovation, so this study only considers task conflicts.

Team members with different backgrounds often have different views on team tasks, which inevitably induces task conflicts (Chen et al. 2012). Conversely, if members of a team are highly homogeneous in their backgrounds, then most members have overlapping knowledge bases, and they may have fewer task conflicts since they do not provoke opposing views (Li et al. 2016). Task conflict can not only help teams collide to produce creative and more effective insights, and integrate these diverse insights into creative and high-quality decisions, thus helping teams achieve both exploratory and exploitative innovation (Camelo-Ordaz et al. 2015; Martin et al. 2019). It can also prevent premature consensus and stimulate more critical thinking (De Dreu 2006), which will promote ambidextrous innovation. In infrastructure project practice, because the cross-functional team members come from different functional departments, they have different views of the project plan and priorities of the project objectives, which will lead to task conflicts (Wu et al. 2020). Besides, Liu and Leitner (2012) also emphasized that conflict is one of the antecedents of ambidexterity in complex engineering project teams. Based on the above discussion, we propose the following hypothesis.

Hypothesis 2: In infrastructure projects, task conflict mediates the relationship between cross-functional team diversity and ambidextrous innovation.

Mediating Role of Expertise Integration

In the "differentiation-integration" framework, differentiated exploratory and exploitative expertise need to be mobilized, coordinated, integrated, and applied (Jansen et al. 2009). Expertise integration refers to the process by which individual professional knowledge are integrated into comprehensive expertise at the team level in the accomplishment of team tasks (Tiwana and Mclean 2005). Different from knowledge transfer or knowledge sharing, expertise integration not only requires sharing individual expertise with other members of the team, but also requires the utilization of this shared expertise at the team level (Faraj and Sproull 2000).

Although expertise is held at the individual level, its value can only be realized if it is integrated into team knowledge base (Okhuysen and Eisenhardt 2002). Team members with different backgrounds have different expertise, and the interactions of diverse teams tend to integrate a better pool of expertise than those of more homogeneous teams, which in turn creates more positive outcomes (Liang and Picken

2011). Integrating individual expertise at the team level can inspire ambidextrous innovation (Jansen et al. 2009). Because individuals usually make suggestions for the implementation and decision-making of the project based on their own expertise, but this expertise is often one-sided and limited (Tiwana and Mclean 2005). While when expertise is integrated, team members can access, explore, and use project-related expertise, which makes it easier to reach a consensus that is more holistic and better balanced between exploratory and applied innovation (Halevi et al. 2015). In infrastructure project literature, it is also emphasized that enhancing the specialization and complementarity of infrastructure project cross-functional teams can create greater value (Lehtinen et al. 2019). Therefore, the following hypothesis is developed.

Hypothesis 3: In infrastructure projects, expertise integration mediates the relationship between cross-functional team diversity and ambidextrous innovation.

Task Conflict and Expertise Integration

Previous studies have confirmed that collaborative response to task conflict will facilitate expertise integration (Amason 1996; Chen et al. 2012). Because task conflict triggers different task-related viewpoints of team members, and these viewpoints convey their different expertise (Amason 1996). Through positive interaction, team members tend to use their expertise to prove their opinions or to refute the dissenters' opinions (Hempel et al. 2009). In view of this, task conflicts provide conditions for integrating various expertise. In infrastructure projects, in order to effectively solve various complex problems in engineering construction, the cross-functional team needs to hold regular meetings. During this process, task conflicts are inevitable, and through a series of discussions, expertise will be integrated within the team (Sheng et al. 2018). Therefore, the following hypothesis is developed.

Hypothesis 4: In infrastructure projects, the cross-functional team task conflict has a positive effect on expertise integration.

Moderating Role of Team Autonomy Support

The "differentiation-integration" framework has generally been validated at the top management team level (e.g., Jansen et al. 2009). Since cross-functional teams are middle-level entities in infrastructure projects, drawing on previous studies of middle-level teams, we added the moderating variable "team autonomy support" to the original framework. Team autonomy support refers to the degree of freedom and discretion that the team provides to team members in their work (Liu et al. 2011). In teams with high team autonomy support, team members can largely determine the pace and method of their works (Volmer et al. 2012), determine implement specific actions and solutions on their own (Gonzalez and de Melo 2018). In the past two decades, team autonomy has gradually become an important topic in team research (Gonzalez and de Melo 2018; Liu et al. 2011). It is worth noting that Gil and Pinto (2018) have emphasized the importance of team autonomy support in infrastructure project management. More and more scholars call for taking team autonomy support as a moderator to explore how it affects various team processes (Chang 2016). In particular, Rico et al. (2007) have emphasized that team autonomy may strongly influence the diversity effects in teams.

With higher team autonomy support, team members have more initiative and freedom to plan and execute their tasks (Gonzalez and de Melo 2018), which may enhance the effect of team diversity, and lead to more task conflicts (Chang 2016). On the contrary, with lower team autonomy support, team members are subject to many restrictions in completing tasks, which leads to their habitual passive acceptance and a corresponding reduction in task conflict (Volmer et al. 2012). Therefore, the following hypothesis is developed.

Hypothesis 5a: Team autonomy support moderates (reinforces) the effect of cross-functional team diversity on task conflict.

In a team with high autonomy support, it creates a better communication and collaboration atmosphere (Chang 2016), which can make full use of the diversity of team members, integrate their expertise, and thus promote the development of high-quality solutions (Rico et al. 2007). In contrast, teams with low autonomy support require team members to follow specific guidelines, which will limit the flow of internal information and knowledge (Lee and Choi 2003), thus weakening the benefits of team diversity and hindering the integration of expertise (Gonzalez and de Melo 2018). In particular, Gil and Pinto (2018) have mentioned that autonomy may facilitate the interactions and integrations in infrastructure project teams. Therefore, the following hypothesis is developed.

Hypothesis 5b: Team autonomy support moderates (reinforces) the effect of cross-functional team diversity on expertise integration.

Team autonomy support can promote knowledge exchange and creative thinking, make full use of the benefits of team diversity, and thus create conditions for the realization of both exploitative and exploratory innovation (Chung et al. 2018). In a team with high autonomy support, team members have more opportunities to implement their new ideas into tasks (Wang and Cheng 2010). Conversely, in a team with low autonomy support, team members have less freedom of action and discretion, they have fewer opportunities to implement their new ideas, and correspondingly fewer team innovations (Volmer et al. 2012). Therefore, the following hypothesis is developed.

Hypothesis 5c: Team autonomy support moderates (reinforces) the effect of cross-functional team diversity on ambidextrous innovation.

Methods

Sample and Data Collection

In order to make the measurement items modified based on classic management scales suitable for measurement in the context of infrastructure projects, a two-round pilot survey was conducted. In the first round, we invited five scholars to check whether the items in the questionnaire were well articulated and could be understood in the context of infrastructure projects. According to the opinions of scholars, we adjusted the original questionnaire. One of the authors of this paper is deeply involved in the Shanghai Pudong International Airport Phase IV construction project. After a cross-functional team meeting, our second round pilot survey was conducted with 11 cross-functional team members of this airport project. These experienced cross-functional team members answered all the questionnaire items and provided feedback about the questionnaire's design. We finally determined the formal questionnaire based on their feedback.

As emphasized above, given the crucial role that cross-functional teams play in fostering ambidextrous innovation in infrastructure projects, this study focuses on cross-functional teams. Correspondingly, the respondents are members of these cross-functional teams, and they are usually the heads of various functional departments in infrastructure projects. Because of this, simple random sampling is not applicable to this study, because this method cannot guarantee that the respondents are the heads of functional departments. This study adopted a purposeful sampling approach (Miles and Huberman 1994). Specifically, we distributed the questionnaire in two ways. First, the two authors of this study, as well as the director of the Urban and Rural Planning Bureau we thank in our "Acknowledgment," provided a wealth of reliable contact information of the infrastructure project leaders (such as project managers, top management team members). Through sending the online questionnaire link targeted to these infrastructure project leaders, and asking them to send this questionnaire to their cross-functional teams, we ensured that the respondents met our research design. Second, surveys were collected on-site in several infrastructure project sites. From November 2019 to May 2020, 50 infrastructure project cross-functional teams/361 team members joined our study. Since team diversity is a team-level property, we excluded teams with fewer than three valid questionnaires (see also in Van Veelen and Ufkes, 2019). Finally, 39 teams/313 respondents were considered valid, with an effective rate of 86.7%. The distribution of infrastructure projects and respondents are shown in Table 1.

(Please insert Table 1 here)

Measures

Team Diversity. The measurement dimensions of team diversity include age diversity, work experience diversity, education level diversity and functional diversity. The questionnaire provides the range options for age, work experience, and education level (see Table 1 for the specific categories), and the functional departments require the respondents to fill in according to their actual situation. Team diversity was calculated using Blau's index (Blau 1977), the calculation formula is: $H = 1 - \sum p_i^2$. In the formula, *i* refers to the number of different categories, and *p* refers to the proportion of team members in each category. Age diversity, work experience diversity, etc. can be calculated by Blau's index respectively, and the average of these items is the team diversity index. And the higher the team diversity index, the greater the team diversity. It is worth noting that team diversity is a team-level index, within the same team, although each team member has different demographic characteristics, their team diversity index is equal.

Task Conflict. Based on the study of Tjosvold et al. (2006) and Jehn (1995), four items were adopted to measure the frequency and extent of the task conflict within the team, such as "have frequent conflicts about ideas," "have a large extent difference of opinion," etc. These items were measured on a seven-point Likert scale, ranging from 1 "completely disagree" to 7 "completely agree."

Expertise Integration. Following the study of Tiwana and Mclean (2005), expertise integration was assessed with four dimensions: the degree to which team members integrate personal expertise at the project level; the degree to which team members' expertise is applied in the project development; the degree to which the project is understood from a systemic perspective; the degree to which team members combine their expertise with project-level knowledge. The rating scale ranged from 1 "completely disagree" to 7 "completely agree."

Team Autonomy Support. To measure the team autonomy support, four measurement items developed by Liu et al. (2011) were used. Specifically, these items involve the degree of team support for members' individual perspectives, the degree to which the team gives members choice, the degree of team restriction and flexibility. We adopted 1 "completely disagree" to 7 "completely agree" to evaluate these items.

Ambidextrous Innovation. In the ambidexterity theory, there is a consensus that ambidextrous innovation is simultaneously pursuing exploratory innovation and exploitative innovation (March 2013; Tushman and O'Reilly 1996). However, there are two different viewpoints. One is that ambidextrous innovation needs the balance between these two innovations (He and Wong 2004), and the other is that ambidextrous innovation needs to maximize the combined effect of these two innovations (Gibson and Birkinshaw 2004; Lubatkin et al. 2006). Cao et al. (2009) synthesized these two viewpoints and developed an operable method for calculating ambidextrous innovation, which has been widely recognized by subsequent ambidexterity studies (e.g., Junni et al. 2013; Lavie et al. 2010). Specifically, Cao et al. (2009) unpacked ambidextrous innovation into two dimensions: balance dimension (BD) and combination dimension (CD). Among them, BD is related to the relative magnitudes or balance of exploratory innovation and exploitative innovation, while CD is related to the combined magnitude of exploratory innovation and exploitative innovation. BD and CD can be respectively calculated by the following formulas: $BD = 5 - |explorative\ innovation - exploitative\ innovation|$, $CD = explorative\ innovation \times exploitative\ innovation$ (Cao et al. 2009).

In the questionnaire, exploratory innovation and exploitative innovation should be measured respectively, and then BD and CD can be calculated based on the above formula to represent ambidextrous innovation (Cao et al. 2009). The scales developed by He and Wong (2004) for exploitative and exploratory innovation are classic. Based on their scale, and combining some studies on the classification of infrastructure innovation (e.g., Mohammadali et al. 2019), we modified the expression of these scale measures. In the specific questionnaire, respondents were asked to evaluate how their cross-functional team allocates attention and resources between the following innovative activities and goals, and evaluate these items on a scale from 1 “strongly disagree” to 5 “strongly agree.” In the questionnaire, items related to exploratory innovation include: “we prefer to apply new facilities or materials,” “we prefer to develop new technologies,” “we prefer to adopt new services” and “we prefer to adopt innovative processes." Exploitative innovation includes "we prefer to improve existing facilities, technologies and processes," "we are concerned about the improvement of the quality of infrastructure projects," "we are concerned about the reduction in the cost of infrastructure projects," "we are concerned about the acceleration of infrastructure project progress." In the current research sample, the exploratory innovation and exploitative innovation scale presented Cronbach's alphas of 0.781 and 0.672, respectively.

Control variables. A number of other factors have the potential to impact infrastructure ambidextrous innovation, but are not variables of interest in this study. We control for infrastructure type, investment and cross-functional team size. Infrastructure type was transformed into a categorical variable before being added into the model (there are four categories, as shown in Table 1). Most of the projects we investigated are under construction, and infrastructure investment was measured by the amount of planned investment. The size of a cross-functional team was measured by the number of members.

Results

First, we evaluated the reliability, internal consistency, and construct validity of the measures (measurement model) (Hair et al., 2016). Second, we divided the conceptual model in Fig.1 into three sub-models and tested the hypotheses path through hierarchical regression. Specifically, we used the PROCESS tool developed by Hayes to perform hierarchical regression (Hayes 2017). Among three sub-models, model TC is the model with task conflict as the dependent variable (mainly testing H2a, H5a), model EI is the model with expertise integration as the dependent variable (mainly testing H3a, H4, and H5b), and model AI is the model with ambidextrous innovation as the dependent variable (mainly testing

H1, H2b, H3b, and H5c). The moderating effect was tested by constructing the interaction between the independent variable and the moderating variable. In addition, the bootstrapping approach (5000 resamples) was used to examine the effect and get robust standard errors for parameter estimates.

Measurement Model

As shown in table 2, Cronbach's α were greater than 0.7 (Hair Jr et al. 2016) in all scales except for the team diversity scale, which was 0.681, indicating an internal consistency. Among 18 items, the loadings of 13 items were higher than 0.7, and 5 items were around 0.6, higher than the threshold of 0.5 (Hair Jr et al. 2016). The values of construct reliability (CR) of each construct exceed 0.8, and were higher than the 0.7 threshold (Bagozzi and Yi 1988), indicating the structural reliability was satisfactory. The AVE values of all constructs were higher than the 0.5 cutoff (Fornell and Larcker 1981), indicating a good convergence validity.

(Please insert Table 2 here)

Structural Model

Table 3 reports the results of hierarchical regression with bootstrapping of 5,000 subsamples. Model TC is a model with task conflict as the dependent variable, and mainly test H2a and H5a. The results show that team diversity has a significant positive effect on task conflict ($\beta = 0.7192$, $p < 0.001$), supporting H2a. While the moderating effect of the team autonomy support on the relation between team diversity and task conflict is not significant ($\beta = -0.0013$, n.s.), not supporting H5a. Model EI is a model with expertise integration as the dependent variable, and mainly test H3a, H4, and H5b. The results show that team diversity has a positive impact on expertise integration ($\beta = 0.2774$, $p < 0.01$), supporting H3a. Task conflict has a positive impact on expertise integration ($\beta = 0.3209$, $p < 0.001$), supporting H4. In addition, we estimated the moderating effect of the team autonomy support on the relation between team diversity and expertise integration (β = -0.1686, p < 0.01), which is contrary to H3b. That is to say, team autonomy support negatively moderates the effect of team diversity on expertise integration. Model AI is a model with ambidextrous innovation as the dependent variable, and mainly test H1, H2b, H3b, and H5c. The results show that team diversity has a significant positive effect on ambidextrous innovation (β = 0.4769, p < 0.001), supporting H1. However, the relationship between task conflict and ambidextrous innovation is not significant (β = 0.0691, n.s.), not supporting H2b. The relationship between expertise integration and ambidextrous innovation is positive (β = 0.1762, p < 0.01), supporting H5. These show that task conflict cannot directly mediate the relationship between team diversity and ambidextrous innovation, and the relationship between them needs to be mediated through expertise integration or other team processes. In addition, we estimated the moderating effect of the team autonomy support on the relation between team diversity and ambidextrous innovation (β = 0.628, p < 0.05), supporting H5c. This suggests that high levels of team autonomy support strengthen the positive relationship between team diversity and ambidextrous innovation.

(Please insert Table 3 here)

We conducted sample slope analysis on H5b and H5c respectively to further interpret the moderating effect (Fig. 2A). Fig. 2A shows that when the level of team autonomy support is high, the positive impact of team diversity on expertise integration is weakened. In contrast, the positive impact of team diversity on ambidextrous innovation is enhanced. However, slope analysis can only show the indirect effect under two different values of the moderating variable, and cannot fully reflect the overall picture of the indirect effect. In order to overcome this shortcoming, this study draws on the practice of some recent studies (Preacher et al. 2007), and used the Johnson-Neyman technique to plot the indirect effect with an accompanying 95% confidence band (Fig. 2B). As shown in Fig. 2B, high levels of team autonomy support weaken the effect between team diversity and expertise integration, strength the effect between team diversity and ambidextrous innovation.

(Please insert Fig. 2 here)

Discussion

Overall, the results indicated that the differentiation and integration of diverse teams provide powerful tactics for fostering ambidextrous innovation in infrastructure projects. Specifically, team diversity was found to have a significant positive impact on ambidextrous innovation of the cross-functional team in infrastructure construction projects (H1). The same results were obtained by Li et al. in a survey of high-tech firms (Li et al. 2016). The differences in the team members' age, work experience, education level, and the functional departments they work in will affect their attentions and preferences. Many team decisions, including the choice between exploratory innovation and exploitative innovation, stem from the conflict and integration of these differences (Junni et al. 2015). Therefore, to achieve ambidextrous innovation, when assembling the cross-functional team, it is important to focus not only on the choices of individual team members, but also on the diversity of the entire team (Liu and Leitner 2012).

In the cross-functional team of infrastructure projects, team diversity has a positive impact on task conflict (H2a). This is particularly true in the practice of infrastructure projects, where cross-functional team members often represent different functional departments, and they have different understandings of the assignment of project tasks and the prioritization of project goals, which can trigger task conflicts

(Wu et al. 2020). Expertise integration partially mediates the relationship between team diversity and ambidextrous innovation in the cross-functional teams of infrastructure projects (H3a, H3b). This is consistent with the results obtained by Tiwana and Mclean (2005) in the information systems development project. In infrastructure project practice, team members with different demographics have different expertise, and diverse teams are better at integrating expertise than homogeneous teams (Lehtinen et al. 2019). Kardes et al. (2013) have also emphasized the high diversity of global megaproject teams, which will promote the integration of expertise. And such teams are more likely to pursue exploratory and exploitative innovations simultaneously (Halevi et al. 2015).

Interestingly, our results show that in infrastructure projects, cross-functional team task conflict has no direct impact on ambidextrous innovation (H2b). However, task conflict can indirectly affect ambidextrous innovation through expertise integration (H4). The result of H2b is in contrast to previous related studies, Wu et al. (2017) found a positive relationship between task conflict and the performance of construction projects in China, Khosravi et al. (2020) found a negative relationship between task conflict and the performance of large-scale infrastructure projects. Regarding H2b, previous studies have also shown that the impact of task conflict on team outcomes is ambiguous, indeed, there is empirical evidence show a positive (e.g., De Clercq et al. 2009), negative (e.g., Camelo-Ordaz et al. 2015), nonsignificant (Liu et al. 2009) association between task conflict and team outcomes. Some studies suggest that different effects of task conflict on team outcomes depend on different responses to the conflict, which can be roughly divided into cooperative and competitive responses (Deutsch et al. 2011). The cooperative responses to task conflict tend to increase the desirable team outcomes, such as team cooperation, satisfaction, innovation, and team performance (Hempel et al. 2009). While the competitive responses may induce relationship conflicts, suspicions and mistrusts, which often negatively impact team outcomes (Simons and Peterson 2000). These are also consistent with our empirical findings that task conflict positively affects ambidextrous innovation through expertise integration. Therefore, in infrastructure projects, cross-functional teams should encourage team members to take cooperative responses to task conflict, and to fully exert the positive impact of the task conflict on the ambidextrous innovation through positive processes such as expertise integration.

Surprisingly, the moderating effects of team autonomy support on the relationship between team diversity and task conflict (H7a, not significant moderation), team diversity and expertise integration (H7b, negative moderation), team diversity and ambidextrous innovation (H7c, positive moderation) present three different results. Correspondingly, ecology theory, agency theory, and strategic choice theory have also proposed contradictory predictions about the impact of team autonomy support on team outcomes. Ecology theory holds that the structure or external influences of the team itself are so decisive that the manager cannot have any systemic influence on the team (Hannan and Freeman 1977), so team autonomy support is unrelated to team processes and outcomes (CAZA 2011). Concerning team autonomy support, agency theory argues that principals must pay close attention to the behaviors of agents, because the agents' personal interests are likely to conflict with the principals' interests (Jensen and Meckling 1979). Agency theory assumes that the more autonomy managers have, the more they can shift resources from team performance to their personal goals (Bottom et al. 2006). As a result, team autonomy support may have a negative impact on team processes or outcomes. Unlike agency theory, which assumes that managers will use the team autonomy support to pursue personal interests at the expense of the team performance, strategic choice theory assumes that managers will use their discretion to benefit the team performance (Child 1972). Strategic choice theory takes into account the importance of the issues such as organizational commitment, promotion opportunities, and job dependence, which can motivate managers to prioritize the interests of the entire team when taking actions (Marlin et al. 1994). Thus team autonomy may have a positive impact on team processes and outcomes. Therefore, current theory does not seem to provide consistent guidance for team autonomy support in management practice (CAZA 2011).

Conclusions

In order to address the practical need to integrate exploratory and exploitative innovations in infrastructure practice, and to fill the gap in the literature that is still unclear on how to foster ambidextrous innovation in infrastructure projects, this study draw on the "difference-integration" framework of ambidexterity theory to deconstruct tactics for fostering ambidextrous innovation in infrastructure projects. The findings suggest that in infrastructure projects, task conflict and expertise integration of diverse cross-functional teams provide powerful and complementary tactics for fostering ambidextrous innovation. The moderating effect of team autonomy support on the impact of team diversity on differentiation and integration tactics presents three different results.

This study makes three contributions to infrastructure project innovation and ambidexterity literature. First, unlike most infrastructure project innovation research, we are not looking at general innovation or one-dimensional innovation, but rather at the comprehensive effect of exploratory and exploitative innovation. As emphasized above, it is urgent to be solved in infrastructure project practice, but existing research only emphasized the importance of ambidextrous innovation in infrastructure projects, and there is a lack of research on how to achieve ambidextrous innovation in infrastructure projects. To bridge this gap, this paper explores tactics for fostering ambidextrous innovation in infrastructure projects by applying the "differentiation-integration" framework to infrastructure projects. In doing so, this study not only enriches the literature on how infrastructure projects foster ambidextrous innovation, but also broadens the application of the "differentiation-integration" framework of ambidexterity theory. Second, previous ambidexterity research mainly focused on the organizational, individual and top management team levels, while in this study, combining the characteristics of infrastructure projects, the cross-functional team was selected as the research object. In this way, this study not only expands the level of ambidexterity research, but also provides a novel interpretation of the role of cross-functional teams in fostering ambidexterity. Third, ambidextrous innovation has traditionally been pursued in relatively permanent organizations (e.g., companies, Worsnop et al., 2016). However, it is because of the one-off, temporary and complex characteristics of infrastructure projects, they need to pursue exploitative and exploratory innovation simultaneously (Davies et al. 2014; Liu and Leitner 2012). Consistent with this, scholars and engineering practitioners are increasingly recognizing that infrastructure projects may be the best context to contextualize ambidexterity into practice (Petro et al. 2019). By responding to this, we have also broadened the application context for ambidexterity research.

Our findings also have some practical implications for infrastructure project practice. First, we confirmed the positive impact of team diversity on ambidextrous innovation, so when assembling the cross-functional team, it is important to pay attention not only to the individual characteristics and traits of team members, but also to the diversity of the whole team. That is, not all members of a cross-functional team are as old and experienced as possible, and diverse teams are better at fostering ambidextrous innovation in infrastructure projects. Second, we confirmed the direct and indirect effects of the task conflict and expertise integration on ambidextrous innovation. These suggest that the cross-functional teams don’t have to worry about task conflicts, which may inspire more collisions of ideas. And team members need to be actively guided to take collaborative responses to task conflicts, which will better facilitate ambidextrous innovation. In infrastructure project practice, in order to effectively allocate and integrate engineering resources, solve and make decisions on various complex problems, the cross-functional teams need to hold regular meetings or special meetings (Sheng et al. 2018). In this process, task conflicts are inevitable, and it is in this process that expertise can be integrated into team-level and stimulate ambidextrous innovation (Liu and Leitner 2012). Third, it is inconsistent with the results of most studies that team autonomy support will positively moderate the relationship between team diversity and team outcomes. In our study, the moderating effects of team autonomy support appear three different results: non-significant, negative and positive. This may be due to the characteristics of infrastructure projects, or it may be due to the limitations of the current research sample, but it is still worth noting that the degree of autonomy support given to the cross-functional team needs to be considered more carefully based on the characteristics of different infrastructure projects.

Some limitations suggest directions for future research. First, the gap in the literature is that it is not yet clear how ambidextrous innovation can be achieved in infrastructure projects, and in this study, we have only validated that differentiation and integration are powerful tactics. However, there are still many other tactics for fostering ambidextrous innovation, but this study has not covered them, therefore, in-depth case studies are needed to guide infrastructure project practices in a more comprehensive way. Second, for the measurement of ambidextrous innovation, similar to previous studies, it was obtained by calculating questionnaire items, although we have modified the questionnaire measurement items based on the infrastructure project context, this approach is still subjective. In infrastructure projects, innovation may be manifested as patents and technology awards. However, since most of the infrastructure projects investigated in this paper are under construction, we have not yet measured innovation in this more objective way, which is the direction of our next research efforts.

Data Availability Statement

Data generated or analyzed during the study are available from the corresponding author by request.

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Table Captions

Table 1. Profiles of infrastructure projects and respondents

Table 2. Measurement model evaluation

Table 3. Structural model evaluation

Note. 5000 bootstrap samples. LLCI / ULCI: The highest / lowest value of the 95% confidence interval.

TD: Team diversity; TC: Task conflict; EI: Expertise integration; TAS: Team autonomy support; AI: Ambidextrous innovation. *＜.05, **＜.01, ***＜.001.

Figure Captions

Fig. 1. Conceptual framework and hypotheses

Fig. 2. Moderating effect test

Table 1. Profiles of infrastructure projects and respondents

Item	Number	Percentage
Infrastructure projects types		
Transportation infrastructures	16	41.0%
Environmental and public facilities	12	30.8%
Energy and hydropower facilities	6	15.4%
Education and health infrastructure	5	12.8%
Respondents information		
Age		
<30	10	3.2%
30-40	90	28.8%
40-50	151	48.2%
>50	62	19.8%
Work experience		
<5	21	6.7%
5-10	60	19.2%
10-15	137	43.8%
>15	95	30.4%
Education level		
High school and below	38	12.1%
Undergraduate	160	51.1%
Master	95	30.4%
Doctor	20	6.4%

Table 2. Measurement model evaluation

Construct/item	Loading	Cronbach's α	CR	AVE
Team diversity (TD)		0.681	0.809	0.518
TD1: Age diversity	0.775			
TD2: Functional diversity	0.663			
TD3: Work experience diversity	0.827			
TD4: Education level diversity	0.590			
Task conflict (TC) (Jehn 1995; Tjosvold et al. 2006)		0.791	0.865	0.617
TC1: Team members have a great deal of disagreement about the work being done.	0.891			
TC2: Team members have frequent conflicts about ideas.	0.741			
TC3: There is a great deal of conflict between the work of team members.	0.748			
TC4: There are a large extent differences of opinion in our team.	0.751			
Expertise integration (EI) (Tiwana and Mclean 2005)		0.704	0.816	0.527
EI1: Members of this team synthesize and integrate their individual expertise at the project level.	0.668			
EI2: Members of this team span several areas of expertise to develop shared project concepts.	0.731			
EI3: Members of this team can clearly see how different pieces of this project fit together.	0.772			
EI4: Members of this team competently blend new project-related knowledge with what they already know.	0.730			
Team autonomy support (TAS) (Liu et al. 2011)		0.716	0.825	0.544
TAS1: Our team is supportive of team members' individual perspectives.	0.842			
TAS2: Our team gives us a great deal of choice.	0.687			
TAS3: Our team is constrained with regard to team members' self-initiation (Reverse coded).	0.637			
TAS4: Our team is flexible.	0.768			
Ambidextrous innovation (AI) (Cao et al. 2009; He and Wong 2004)		0.826	0.917	0.847
Balance dimension of ambidexterity (BD)	0.889			
Combined dimension of ambidexterity (CD)	0.951			

Table 3. Structural model evaluation

	Model TC				Model EI				Model AI			
Variables	Coeff	SE	LLCI	ULCI	Coeff	SE	LLCI	ULCI	Coeff	SE	LLCI	ULCI
TD	.7192***	.0626	.5960	.8425	.2774***	.0783	.1234	.4314	.4769***	.0757	.3279	.6259
TC	—	—	—	—	.3209***	.0597	.2034	.4384	.0691$^{n.s.}$	.0592	-.0475	.1856
EI	—	—	—	—	—	—	—	—	.1762**	.0543	.0694	.2830
TAS	-.0217$^{n.s.}$	.0527	-.1253	.0819	.0999$^{n.s.}$	.0550	-.0084	.2081	.0524$^{n.s.}$	.0524	-.0508	.1556
TD×TAS	-.0013$^{n.s.}$	.0502	-.0999	.0974	-.1686**	.0524	-.2717	-.0655	.0628*	.0505	.0366	.1622
C.Type	.0421$^{n.s.}$	.0466	-.0496	.1338	-.1043$^{n.s.}$	.0488	-.2002	.0084	-.0031$^{n.s.}$	.0466	-.0947	.0886
C.Investment	-.0005$^{n.s.}$	.0004	-.0013	.0002	-.0011**	.0004	-.0019	-.0003	.0003$^{n.s.}$	.0004	-.0004	.0011
C.Team size	.0071$^{n.s.}$	.0174	-.0271	.0412	-.0213$^{n.s.}$	.0181	-.0570	.0143	.0389*	.0172	.0050	.0728
R^2		.5042				.4609				.5168		
F		51.8670				37.2456				40.6424		

Note. 5000 bootstrap samples. LLCI / ULCI: The highest / lowest value of the 95% confidence interval.

TD: Team diversity; TC: Task conflict; EI: Expertise integration; TAS: Team autonomy support; AI: Ambidextrous innovation. *< .05, **< .01, ***< .001.

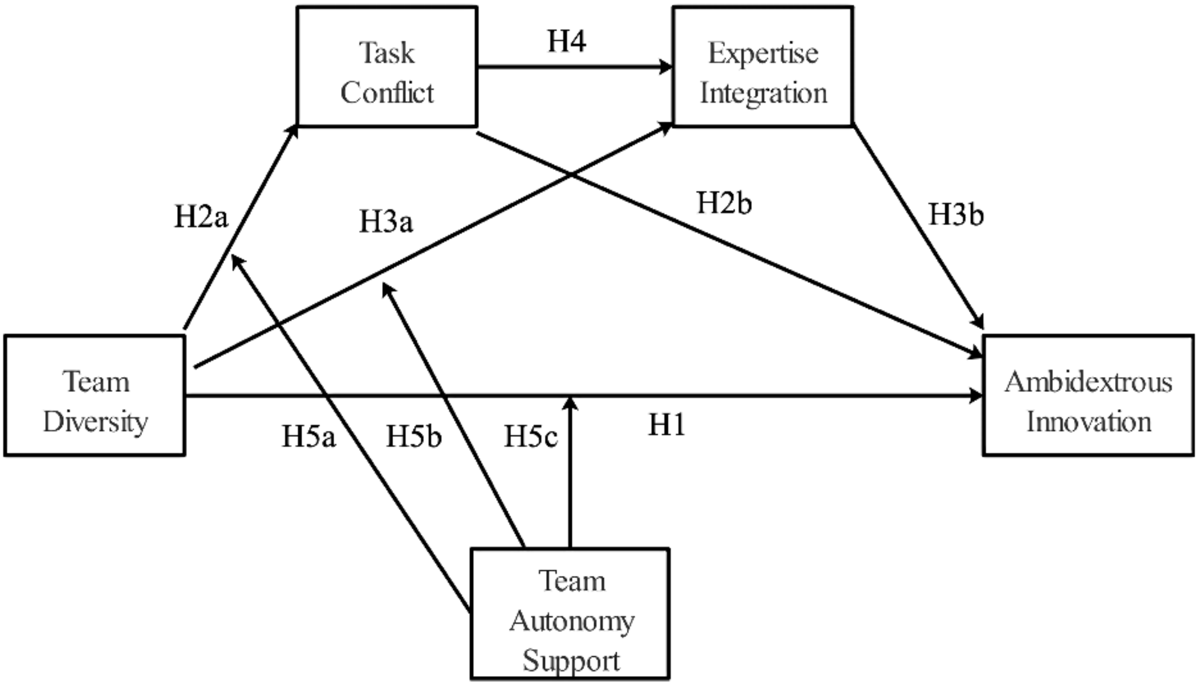
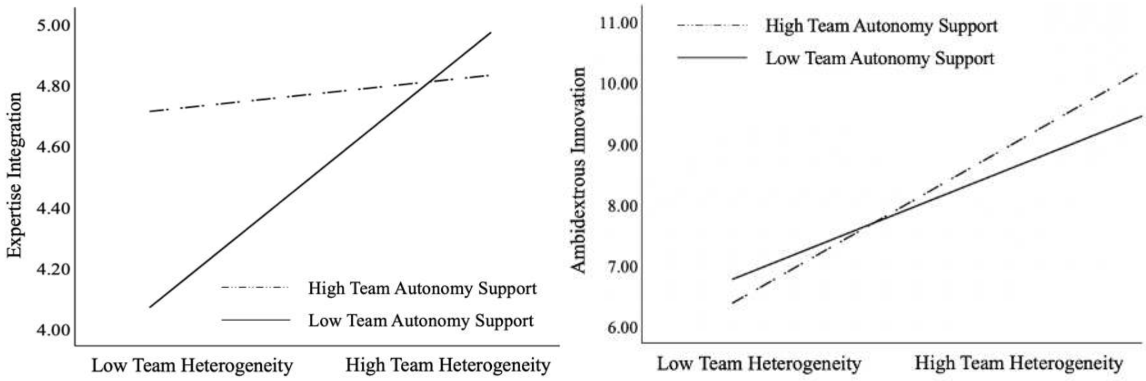
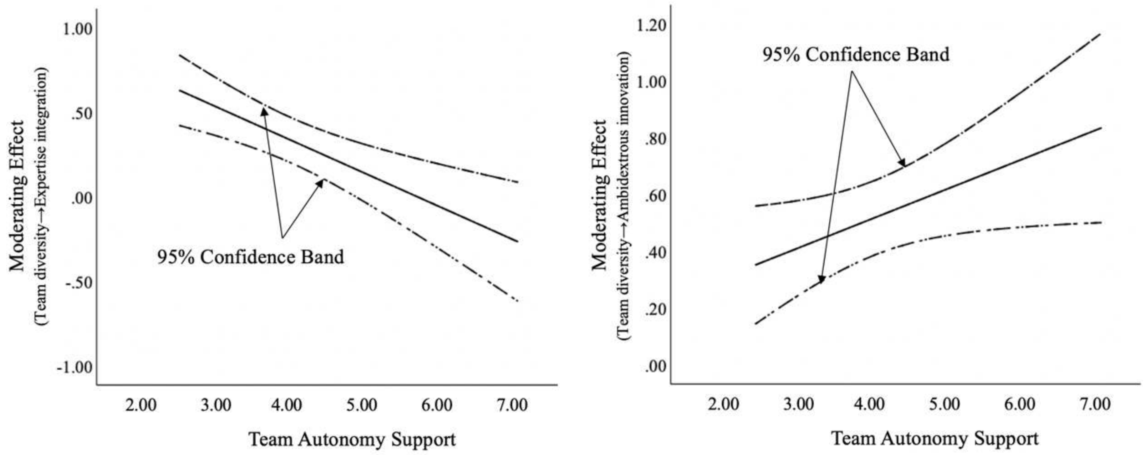


Fig. 1. Conceptual framework and hypotheses.



A. Slope analysis



B. Johnson-Neyman outputs

Fig. 2. Moderating effect test.