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Unraveling the Driving Factors of Team Performance: The Impact of Team Composition and Collaboration Relationships on Project Teams

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Abstract

With research project teams increasingly serve as engines of scientific breakthroughs, understanding the factors driving their performance is essential and urgent. This study examines the effects of team composition (team size, gender diversity), internal collaboration (network density), and external collaboration (domestic, international, and industry partnerships) on team productivity and team impact. Using a sample of 206 research projects funded by the National Natural Science Foundation of China (NSFC), we employ Ordinary Least Squares (OLS) regression and Lindeman-Merenda-Gold (LMG) analysis to identify the most influential factors of team performance. Our results indicate that domestic and international collaborations significantly drive team productivity, while international collaboration also plays a key role in enhancing team impact. An internally dense network negatively affects team productivity but positively contributes to team impact, underscoring the nuanced nature of collaborative dynamics. In contrast, team size and gender diversity are not significant drivers for either outcome. Overall, these findings enrich a multidimensional understanding of the complex relationships between team characteristics and project performance, and offer actionable insights for managers, policymakers, and funders seeking to optimize team performance.

Introduction

In an era of rapidly evolving scientific and technological advancements, the complexity of research problems often exceeds the capacity of any single individual or discipline. Consequently, collaborative project teams have emerged as core vehicles for driving innovation (Liu, Wang, & Yang, 2025). Such teams integrate diverse expertise and resources, enabling them to address multifaceted challenges more effectively than individual researchers. Funded research projects, in particular, have been linked to a greater number of publications and high-impact outputs (Langfeldt, Bloch, & Sivertsen, 2015). As the impact and innovation performance of these project teams garner increasing attention, how the compositional features of

teams affect their performance has become a central concern for researchers. For example, recent studies underscore the importance of team size and gender diversity as critical factors influencing scientific team performance (Tang, Shi, Wu, & Li, 2023; Zhang et al., 2024; Zhao et al., 2024). Another portion of research has focused on collaboration relationships among the research and innovative activity (Whittington, 2018), and found that both internal collaboration networks and external partnerships (domestic, international, or cross-sector) significantly shape research outcomes.

Despite extensive research on team-based innovation, relatively few studies focus on research project teams (Liu et al., 2025), and many of those investigate only one dimension, such as team composition or a single facet of collaboration. Consequently, it remains unclear how multiple team characteristics collectively affect team outcomes and, crucially, the relative impact each dimension exerts. This gap is particularly relevant for research project teams, where insights into the degree of influence from team composition and collaboration relationships have important implications for improving productivity and generating high-impact publications. Motivated by this gap, this study addresses two key questions: (1) Do team composition, internal collaboration, and external collaboration significantly affect performance in research project teams? and (2) To what extent do these factors influence team performance, and which factor has the most significant impact? By addressing these questions, the study aims to offer an evidence-based perspective on how a multidimensional view of team characteristics can help optimize research outcomes. The findings will offer valuable insights for project managers and policymakers, especially in the context of research-based projects funded by institutions such as the NSFC.

Research Hypotheses

Drawing from the perspectives of team composition and collaboration relationships, we identify several key factors influencing team performance. These include team size, gender diversity, collaboration network density, as well as domestic, international and industry collaboration.

Team composition and team performance. Regarding team size, multiple studies reveal a curvilinear or inverted U-shaped pattern linking team expansion to productivity and impact. For instance, Zhao et al. (2024) found that although increasing the number of "thought leaders" can enhance team performance initially, excessive expansion reduces disruptive potential. Similarly, Tang et al. (2023) detected that while co-authorship generally elevates citation impact, indiscriminate growth of teams may not be prudent, echoing Zhu et al.'s evidence of diminishing returns beyond an optimal threshold (Zhu, Liu, & Yang, 2021). Moreover, Perović, Radovanović, Sikimić, and Berber (2016) found that smaller research teams often prove more productive. Turning to gender diversity, gender diversity in scientific teams can lead to better outcomes. Teams with gender heterogeneity can produce higher-quality publications. Zhang et al. (2024) demonstrated that moderate inter-gender collaboration promotes greater disruptive knowledge relative to single-gender teams. However, some research findings do not always support the

conclusion that gender diversity can definitely improve team performance. Wang, Wu, and Li (2024) detected an inverse U-shaped link between the proportion of women scientists and citation impact. Additionally, Sandström and Van Den Besselaar (2019) found no performance penalty for gender diversity. Therefore, the study proposes the following hypotheses:

H1a: Team size positively influences team productivity.

H1b: Team size positively influences team impact.

H2a: Gender diversity positively influences team productivity.

H2b: Gender diversity positively influences team impact.

Internal collaboration and team performance. Internal collaboration networks significantly shape research outcomes. For instance, Shalley and Perry-Smith (2008) utilized network analysis to discover that teams characterized by strong relational ties, as well as those with weaker ties, exhibited the highest levels of creativity. Singh, Tan, and Mookerjee (2011) distinguished between internal and external cohesion within team networks, and noted a positive correlation between internal cohesion and team productivity. Meanwhile, Ma, Ba, Zhao, and Sun (2023) highlighted that balanced "social capital" within and beyond the team, and collaboration features that combine internal cohesion with external linkages support high-quality scientific breakthroughs, suggesting the value of flexible and well-configured network relationships. Therefore, the study proposes the following hypotheses:

H3a: Internal network density positively influences team productivity.

H3b: Internal collaboration network density positively influences team impact.

External collaboration and team performance. In terms of external collaboration, studies consistently show that international collaborations often yield higher citation counts. Specifically, papers resulting from international or multinational partnerships generally receive more citations compared to those involving only domestic collaborations (Persson, 2010). Likewise, Abramo, D'Angelo, and Costa (2019) observed that research teams with higher levels of internationalization enjoy increased citation probabilities. Additionally, it has been proven that research teams engaging in industry-university-research collaboration are highly effective in promoting innovative research (Gray & Sundstrom, 2010; Skute, Zalewska-Kurek, Hatak, & de Weerd-Nederhof, 2019). Some research points out that this kind of collaboration has a significant positive impact on the research productivity of university research teams (Chen & Wang, 2021). Therefore, the study proposes the following hypotheses:

H4a: Domestic collaboration positively influences project team productivity.

H4b: Domestic collaboration positively influences project team impact.

H5a: International collaboration positively influences project team productivity.

H5b: International collaboration positively influences project team impact.

H6a: Industry collaboration positively influences project team productivity.

H6b: Industry collaboration positively influences project team impact.

Data and methods

This study focuses on the Innovative Research Groups funded by the NSFC. The sample consists of 206 research teams working on projects funded by NSFC from 2007 to 2024 (completed projects). These teams are involved in eight scientific fields.

We initiated the data collection process by extracting the number of members and their names from the official project information provided by the NSFC. Subsequently, we conducted an in-depth online investigation. By exploring academic profiles on institutional websites, professional networking platforms, and other reliable online sources, we were able to determine the gender of each team member. This information was then used to calculate the team size (the total number of members) and team gender diversity (using the Blau index).

This study utilized the Web of Science database as the data source for retrieving the publications of research teams. Based on the unique project grant numbers, we searched the Web of Science database. Subsequently, the retrieved publication data was imported into the ItgInsight software (http://itginsight.com/) for author cleaning. After the cleaning process, the co-authorship matrix of team members was exported. Based on the co-authorship matrix, the R programming language was utilized to construct the co-authorship network of team members. Through this network, internal collaboration network density is calculated. Finally, the search results from the Web of Science database were linked to the Incites database. In the Incites database, data on the indicators of Web of Science Documents and Category Normalized Citation Impact (CNCI), and indicators related to industry collaborations, domestic collaborations, and international collaborations were obtained.

Based on the collected data, we utilized the descriptive statistics, correlation analysis, regression analysis to analyze the impact of various factors on team performance. Furthermore, the Lindeman-Merenda-Gold (LMG) method was used to assess the relative importance of each independent variable in explaining the variance of the dependent variable.

Results

Descriptive statistics. After acquiring the data, the variables were measured, and thus the descriptive statistical analysis was performed. The results are shown in Table 1.

Correlation Analysis. The Pearson correlation analysis was conducted on variables including Project_Duration (PD), Team_Size (TS), Gender_Diversity (GD), Network_Density (ND), Domestic_Collaborations (DC), International_Collaborations (ITC), Industry_Collaborations (IDC), Web_of_Science_Documents (WOSD) and Category_Normalized_Citation_Impact (CNCI). The results are presented in Figure 1.

Table 1. Descriptive statistical analysis of variables.

	Sample size	Min.	Max.	Mean	Std_dev	Median
Project_Duration	206	3	9	6.379	1.401	6
Team_Size	206	4	18	9.204	1.601	10
Gender_diversity	206	0	0.5	0.197	0.171	0.18
Network_Density	206	0.244	1.667	0.6	0.281	0.533
Domestic_Collaborations	206	2	939	101.99	94.99	81.5
International_Collaborations	206	0	356	65.267	54.005	51.5
Industry_Collaborations	206	0	81	4.903	10.586	1
Web_of_Science_Documents	206	6	1231	267.544	202.923	217
Category_Normalized_Citation_Impact	206	0.319	5.842	1.504	0.769	1.349

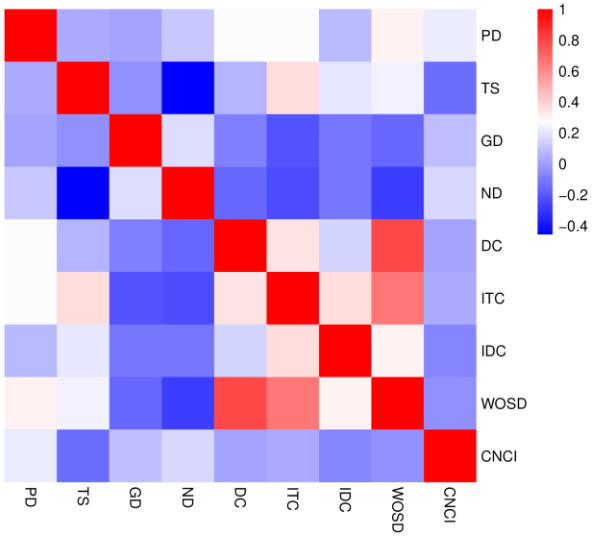

Figure 1. Correlation analysis of variables.

Regression analysis. This study employed the regression analysis to examine the relationships between a set of independent variables and two dependent variables: the Web of Science Documents and Category Normalized Citation Impact. Additionally, two control variables were included: Project_Duration (PD) and Research_Field (RF). Table 2 shows the regression results. As shown in Table 2, domestic collaborations and international collaborations stand out as significant drivers of team productivity, while international collaborations have notable effects on team impact. Notably, a denser internal network negatively influences team productivity but positively associates with team impact. By contrast, team size and gender diversity do not demonstrate significant effects on either outcome. Therefore, hypotheses of H3b, H4a, H5a and H5b are supported. And H1a, H1b, H2a, H2b, H3a, H4b, H6a and H6b are not supported.

Lindeman-Merenda-Gold (LMG) analysis. Table 3 presents the value of relative importance metrics in the LMG analysis for both models, where the Domestic_Collaborations shows the highest explanatory power, indicating that domestic collaborations contribute the most to the variation in Web of Science documents. The International_Collaborations also ranks high. For team impact, the control variables of Research_Field and Project_Duration have the highest explanatory contribution. Other variables show relatively low values. Additionally, the proportion of variance explained by the two models is 84.5% and 20.9%, respectively.

Table 2. Brief regression analysis results.

Terms	*Web_of_Science_Documents*				*Category_Normalized_Citation_Impact*			
	Coef	*Std. Err*	*t*	*p*	*Coef*	*Std. Err*	*t*	*p*
Team_Size	-2.96	4.155	-0.712	0.476	-0.045	0.051	-0.873	0.383
Gender_Diversity	23.665	35.925	0.659	0.51	0.412	0.402	1.024	0.306
Network_Density	**-52.394**	**19.189**	**-2.73**	**0.006****	**0.418**	**0.21**	**1.991**	**0.046***
Domestic_Collaborations	**1.094**	**0.127**	**8.589**	**0.000*****	-0.001	0.001	-1.01	0.312
International_Collaborations	**1.437**	**0.151**	**9.517**	**0.000*****	**0.002**	**0.001**	**2.092**	**0.036***
Industry_Collaborations	-0.184	0.435	-0.424	0.672	0	0.004	0.055	0.956
R^2	0.845				0.209			
R^2(within)	0.833				0.151			

Note: * p<0.05, ** p<0.01, *** p<0.001

Table 3. Relative importance in the LMG analysis for both models.

	Web_of_Science_Documents	*Category_Normalized_Citation_Impact*
Research_Field	0.174	0.116
Project_Duration	0.040	0.040
Team_Size	0.014	0.012
Gender_diversity	0.006	0.006
Network_Density	0.025	0.022
Domestic_Collaborations	0.348	0.001
International_Collaborations	0.213	0.009
Industry_Collaborations	0.025	0.002

Conclusion and discussion

This study aims at understanding how team composition, internal collaboration and external collaboration affect the performance of research project teams. Regarding team productivity, domestic and international collaborations have been identified as significant positive drivers. For team impact, international collaborations have a notable positive effect. Notably, the internal network density shows a negative impact on team productivity but a positive association with team impact. However, team size and gender diversity do not show statistically significant effects on either team productivity or impact. Additionally, the LMG analysis reveals that domestic collaborations have the highest explanatory power for team productivity, followed by international collaborations. For team impact, the control variables of RF and PD

have the highest explanatory contributions. Most of these results are understandable. Both internal and external collaboration relationships have a significant impact on team performance. However, team size and gender diversity are not statistically significant, perhaps due to the interplay of other contextual variables like research discipline and project duration.

Our findings contribute to the existing literature on team-based innovation, especially in the context of research project teams. Previous studies often focused on single-dimension investigations. Our multi-dimensional analysis shows that different aspects of team characteristics have distinct effects on team performance. These findings can provide actionable insights for project managers and policymakers, especially in the Innovative Research Groups funded by the NSFC.

One major limitation of this study is that the model for team impact only explains 20.9% of the variance, indicating that there are many unaccounted-for factors. This suggests that future research should explore additional variables that may influence team impact. Moreover, the role of moderating and mediating variables in the relationships between team composition, collaboration relationships and team performance should be further explored. Furthermore, to gain a more profound understanding of how to achieve the success of project teams, future research should conduct causal inference analysis, such as the application of propensity score matching (PSM).

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