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EDITED BY

Benito Yáñez-Araque,
University of Castilla-La Mancha, Spain

REVIEWED BY

Delali A. Dovie,
University of Ghana, Ghana
Dimitrios Kotsifakos,
University of Piraeus, Greece

*CORRESPONDENCE

Hui Han
✉ qiaoqiaochang@163.com

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Meta-analysis of supervisor support and postgraduate creativity: evidence from a sample of Chinese students

Qiaoli Chang¹, Hui Han^{2*} and Dexin Hu¹

¹School of Education, Tianjin University, Tianjin, China, ²School of Public Management, Inner Mongolia University, Inner Mongolia, China

Introduction: With the growing number of Chinese postgraduate students, enhancing their creativity has become a pressing issue in Chinese higher education. This meta-analysis aimed to investigate the relationship between supervisor support and postgraduate creativity using a sample of Chinese students and to explore potential moderating variables.

Method: The study incorporated 62 primary studies involving 51,640 Chinese graduate students.

Results: The results revealed that supervisor support was significantly and positively associated with postgraduate creativity. Meta-regression and subgroup analyses showed that while postgraduate students' gender did not moderate this relationship, degree level, academic discipline, and type of higher education institution did. Specifically, supervisor support had a stronger correlation with creativity at the master's level compared to the doctoral level. Similarly, the relationship was stronger in the scientific and technical fields than in the humanities, social sciences, medical sciences, and agriculture. Additionally, supervisor support was more positively correlated with creativity in general universities compared to key universities.

Conclusion: These findings offer valuable insights for further research on the impact of supervisor support on postgraduate creativity.

KEYWORDS

China, postgraduate, creativity, supervisor support, meta-analysis

1 Introduction

Postgraduate education plays an important role in promoting national innovation and development (Jibao et al., 2015), and enhancing postgraduate creativity is a significant issue in graduate student training (Zhang et al., 2022a). The supervisor responsibility system in Chinese graduate education positions supervisors as key players in cultivating postgraduate creativity (Zhang et al., 2023). The relationship between supervisor support and postgraduate creativity has attracted extensive scholarly attention, leading to numerous empirical studies. For example, Zhang et al. (2022a) argued that supervisors' academic capital can stimulate postgraduate creativity (Zhang et al., 2022a; Han et al., 2022) found that supervisors' personal support and autonomy support help postgraduates overcome obstacles in innovation activities; Zhang et al. (2022b) suggested that supervisors' autonomy support has a positive impact on postgraduates' innovative behavior. Despite studies showing a significant correlation between supervisor support and postgraduate creativity, there is a lack of meta-analytical reviews in this field. This study

aimed to use a meta-analysis to comprehensively report the correlation between supervisor support and postgraduate creativity in China and to explore potential moderators influencing this relationship. While existing research suggests that supervisor support can indirectly influence postgraduate creativity through mediating variables such as personal initiative (Wu et al., 2018), innovation self-efficacy (Zhang B.-S. et al., 2021), and learning commitment (Zhang et al., 2023), this study focused exclusively on its direct effects to ensure a manageable scope of literature. Additionally, only four moderating variables were considered: gender, degree, discipline, and type of higher education institution.

1.1 Supervisor support

It is widely recognized that postgraduate students face various difficulties during their research training. As the primary source of guidance and support for postgraduates, supervisors need to provide different types of support to help students overcome potential difficulties and obstacles (Han et al., 2022). Therefore, supervisor support refers to a series of supportive behaviors demonstrated by supervisors during the process of guiding postgraduate students (Zhang et al., 2022b). In early studies, researchers discovered that supervisors' academic support and personal support are essential for enhancing postgraduate students' creativity (Ballard and Clanchy, 1993). Academic support refers to the assistance provided by supervisors to postgraduates in relation to their research tasks. This includes helping postgraduates establish clear goals and expectations, assisting them in planning and conducting academic activities, and providing practical resources and support for their research tasks (Overall et al., 2011). Personal support, on the other hand, involves supervisors helping postgraduates overcome research obstacles and alleviate personal stress through respect and confidence-building (Overall et al., 2011). However, the inherently challenging nature of research innovation has led some scholars to gradually realize that postgraduates not only need supervisors to impart skills but also need to become autonomous researchers with sustained motivation (Manathunga and Goozée, 2007). Therefore, while providing academic and personal support, supervisors should also balance guidance with students' autonomy (Manathunga and Goozée, 2007), meaning that autonomy support is also an important dimension of supervisor support (Overall et al., 2011). Specifically, autonomy support involves supervisors acknowledging students' viewpoints, encouraging them to express their ideas openly, and providing opportunities for students to make their own decisions (Overall et al., 2011). In summary, this study uses academic support, personal support, and autonomy support as specific indicators of supervisor support, and conducts literature retrieval and selection based on these criteria.

1.2 Postgraduate creativity

The strong correlation between scientific research and innovation positions postgraduates as a crucial link between technological advancement and scientific progress (Xu et al., 2023). Postgraduate creativity has become a key indicator for assessing

the effectiveness of postgraduate training (Chen and Li, 2018). However, measuring postgraduate creativity remains a challenge. Some scholars have used established creativity scales, such as those developed by Scott and Bruce (1994), Zhang et al. (2022b), Zhou and George (2001), Xu (2022), Robnett and Chemers (2015), and Yao and Yu (2019). Others have designed their own scales tailored to specific research objectives (Shu, 2017). Despite variations in measurement tools, the Componential Theory of Creativity suggests that creativity results from the interaction of three fundamental factors: domain-relevant skills, creativity-relevant skills, and intrinsic motivation (Amabile and Pratt, 2016). The measurement indicators of postgraduate creativity in current research can be summarized into three aspects: Academic ability, which measures postgraduate students' professional knowledge and skills (Zhao, 2023); Creative results (Wu and Luo, 2020) or creative performance (Wang and Cai, 2022), which reflect postgraduate students' ability to explore new paths and solve complex problems in novel ways; Creative awareness, which assesses the intrinsic innovative drive of postgraduate students (Yang, 2024). Therefore, this study uses academic ability, creative awareness, creative results, and creative performance as specific indicators of postgraduate creativity, and bases the literature search and screening on these criteria.

1.3 The relationship between supervisor support and postgraduate creativity

The relationship between supervisors and postgraduates is more closely aligned than the conventional teacher-student dynamic (Zhang et al., 2022a). Supervisor support has been shown to positively influence postgraduate creativity (Wang et al., 2013). As primary academic mentors, supervisors provide direct support for postgraduate innovation by offering academic resources, enhancing research skills, and assisting with planning and design (Han et al., 2022). Second, personal support from supervisors can help alleviate postgraduates' stress. When postgraduates receive care, understanding, encouragement, and appreciation from their supervisors, they enhance their psychological capital, including self-efficacy, adaptability, and resilience. This leads to increased interest in research activities, a strong commitment to goals, and the ability to respond effectively to challenges, resulting in positive behaviors and outcomes (Ahmed et al., 2017). Third, autonomy support emphasized student contentment. When supervisors grant full research autonomy and trust in the research process and encourage students to take initiative in solving problems, postgraduates' independent thinking, motivation to innovate, and research output are significantly enhanced (Xu, 2022). However, despite existing empirical studies verifying the correlation between supervisor support and postgraduate creativity, some studies suffer from low quality because of sampling methods, sample size validity, and measurement instrument reliability. This has resulted in unclear conclusions regarding the extent of the correlation between supervisor support behaviors and postgraduate creativity. Therefore, there is a need to integrate the current research findings at the macro level to further clarify the link between supervisor support and postgraduate creativity.

1.4 Potential moderating variables of supervisor support and postgraduate creativity

1.4.1 Gender

Socially ingrained gender norms and implicit gender discrimination within academic institutions can diminish female postgraduates' motivation to engage in innovative activities (Mota et al., 2012). Additionally, women are more likely to experience pressure, anxiety, and apprehension in their research (Conrad, 2017) and are more susceptible to academic procrastination due to fear of failure (Ghosh and Roy, 2017). However, when female postgraduates perceive their supervisors as caring, supportive, and helpful, they are more likely to communicate openly and honestly while seeking guidance and assistance (Conrad, 2017). Thus, supervisor support plays a crucial role in alleviating these negative perceptions among female postgraduate students (Lei et al., 2018). This positive interaction helps alleviate the negative impact of emotions. Accordingly, this study hypothesizes that postgraduate gender moderates the correlation between supervisor support and creativity.

1.4.2 Degree

Master's and Ph.D. degrees represent distinct stages of graduate education, each with specific objectives. Generally, a master's degree serves as the foundational phase of academic training (Ouyang and Hu, 2020). As novices, master's students often struggle to engage in independent innovative activities due to limited academic literacy and insufficient mastery of professional knowledge and skills (Wu et al., 2014). Consequently, they rely more on supervisory guidance and support. In contrast, doctoral students require not only advanced professional knowledge and skills but also academic passion, intellectual curiosity, and the resilience to overcome challenges, which are primarily internally driven (Huang and Jin, 2016). Through continuous research, critique, and reflection, they contribute uniquely to the body of knowledge (Qin et al., 2022). This process heightens the need for supervisory support to foster autonomy in innovation (Overall et al., 2011). Accordingly, this study hypothesizes that degree type moderates the relationship between academic, personal, and autonomy support and postgraduate creativity.

1.4.3 Discipline

Numerous studies have investigated the impact of disciplinary attributes on the relationship between supervisor support and postgraduate creativity. For example, Brodin (2018) examined factors influencing Ph.D. students' creativity in Switzerland and found that, in education and philosophy, postgraduate creativity was shaped by supervisors' authority, whereas students in music performance experienced relatively less supervisory control. Zheng et al. (2022) argued that, compared to the humanities and social sciences, academic support from supervisors in STEM fields has a stronger influence on postgraduate students' innovative abilities. Similarly, Pan and Gu (2022) found that, compared to medical fields, postgraduate creativity in natural sciences and engineering is more significantly affected by supervisor support. Li M.-L. et al.

(2022) analyzed the academic development of engineering doctoral students and concluded that supervisor guidance plays a crucial role in enhancing their academic abilities. Accordingly, this study hypothesized that discipline moderates the relationship between supervisory support and postgraduate creativity.

1.4.4 Type of higher education institution

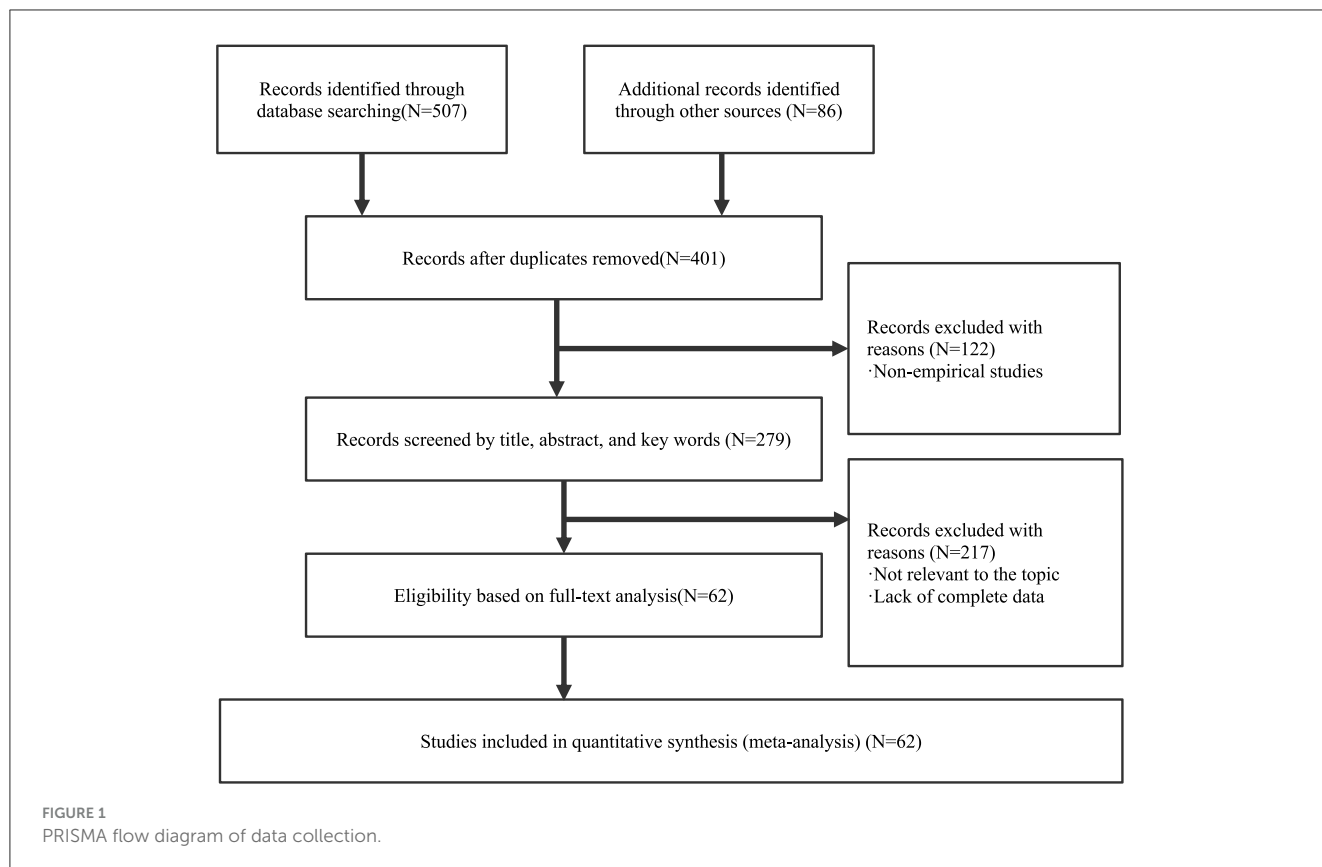
Higher education institutions play a vital role in postgraduate education, and institutional differences can influence the relationship between supervisor support and postgraduate creativity (Shen, 2022). Higher-ranked universities typically possess greater resources, offering advanced research platforms, extensive academic support, and a stimulating intellectual environment, all of which enhance postgraduate students' innovative capabilities (Liu Y.-Y., 2022). These institutions also attract high-achieving students with strong professional foundations, higher personal initiative, greater learning commitment, and enhanced self-efficacy compared to those at lower-ranked universities (Peng and Hu, 2021). As a result, students at top-tier universities are more likely to engage proactively in innovative activities (Yin and Gao, 2014). Based on these considerations, this study hypothesizes that the type of higher education institution moderates the relationship between supervisory support and postgraduate creativity.

By reviewing previous literature on supervisor support and postgraduate creativity, we identified gender, degree, discipline, and type of higher education institution as potential moderating factors in this relationship. Therefore, in addition to conducting a meta-analysis to confirm the relationship between supervisor support and postgraduate creativity, this study will examine whether these variables serve as moderators.

2 Methods

2.1 Literature search and exclusion criteria

This study aimed to cover all relevant studies to date. First, an extensive search was conducted using keywords such as academic support, personal support, autonomy support, supervisor support, creativity, creative competence, creative behaviors, creative performance, academic results, creative thinking, and creative results. China and Chinese were searched across databases, including CNKI, Wanfang, Wipro, Web of Science, Scopus, ProQuest, ScienceDirect, and EBSCO. Second, literature tracking was performed by examining references in the acquired literature to supplement and enhance data comprehensiveness. Third, the literature was selected according to the following criteria: (a) the study must be a quantitative empirical study; (b) the subjects must be Chinese graduate students; (c) the paper must be written in Chinese or English; (d) the study must explore the relationship between at least one dimension of supervisor support—academic support, personal support, or autonomy support—and postgraduate creativity; (e) the paper must provide complete data, such as sample size, mean, standard deviation, *p*-value, Pearson's correlation coefficient, or any statistic that can be converted into a correlation coefficient (Wu and Fu, 2024); and (f) for duplicate publications, only the one with the most comprehensive reporting was selected (Jin et al., 2023). We



screened the literature using the PRISMA for Systematic Reviews and Meta-Analyses (Page et al., 2021) (Figure 1).

2.2 Literature quality assessment and coding

Literature is the primary source of meta-analyses; however, researchers may have varying perceptions of quality (Boyle, 1998). The inclusion of inaccurate literature can result in misleading meta-analysis outcomes (Orwin and Vevea, 2019). Therefore, this study utilized the Literature Quality Assessment Scale developed by Zhang et al. (2019) to systematically evaluate the sample representation, measurement tools, and result analyses. Two raters assessed the literature based on the following criteria: (a) sampling method (2 points for random sampling, 1 point for non-random sampling, 0 points for failure to report); (b) sample effectiveness rate (2 points for a rate of 90% and above, 1 point for a rate between 80% and 90%, and 0 points for a rate below 80% or not reported); (c) reliability of the measurement instrument (2 points for reliability of 0.8 and above, 1 point for reliability between 0.7 and 0.8, and 0 points for reliability below 0.7 or not reported); (d) publication level (2 points for SSCI and CSSCI journals, 0 points for general journals, dissertations, and conference papers) (Wu et al., 2024). A concordance *Kappa* value of 0.613 was calculated for both raters, indicating a good level of agreement (Zhang et al., 2019).

Basic information about the included literature was coded (Table 1), and effect sizes were coded in more detail as follows: (a) if a study had multiple independent samples, the effect

size for each independent sample was coded separately; (b) the correlations between different indicators of supervisor support and postgraduate creativity were coded separately; and (c) if a study reported multiple correlations between supervisor support and postgraduate creativity, the mean values were used. The literature coding was conducted independently by two researchers. For data with inconsistent coding results, discussions were held to verify and correct the data accuracy.

2.3 Data analysis

This study utilized a comprehensive meta-analysis software CMA 3.0 for data analysis. The Pearson correlation coefficient r , commonly employed in meta-analyses in management and education, was used as the effect size (Zhang et al., 2024). Regression analysis β -values reported in the original literature were converted to r using the formulas $r = \beta \times 0.98 + 0.05$ for ($\beta \geq 0$) and $r = \beta \times 0.98$ ($\beta < 0$) (Peterson and Brown, 2005). Given that random effects models allow for broader generalizations (Borenstein et al., 2021), a random utility model was employed for data analysis. Heterogeneity, reflecting the variation in effect sizes between populations, was assessed using Q , I^2 , and T^2 statistics (Michael, 2019). Significant Q values ($p < 0.05$) indicated heterogeneity of effect sizes, I^2 values $> 75\%$ suggested high heterogeneity, and T^2 provided an estimate of the variance of true effect sizes (Borenstein et al., 2010). Publication bias, that is, selective publication by researchers, was assessed using the fail-safe number (Nfs) and Egger's test. Nfs values $> 5k + 10$ (where

TABLE 1 Literature coding information.

Author (year)	N	Male (%)	Degree ^a	Discipline ^b	HEI type ^c	Variable ^d	Literature type
Liu and Yao, 2010	214	61	M	NR	211	SS&PC	Journal
Zhu et al., 2011	10,850	51	D&M	HS&ST&A&M	Double First-class	SS&PC	Journal
Wang (2013)	216	71	D&M	HS&ST	NR	SS&PC	Dissertation
Li (2015)	156	77	D	ST	Double First-class	CS/PS&PC	Dissertation
Jibao et al. (2015)	216	65	D&M	HS&ST	Double First-class	SS&PC	Journal
Wang et al. (2016)	148	76	D	NR	NR	AS&PC	Journal
Tan (2016)	206	68	M	HS&ST	NR	AS&PC	Dissertation
Xie and Han (2016)	256	72	D&M	HS&ST&M	NR	SS&PC	Journal
Zhu (2017)	455	45	M	HS&ST	Double First-class	PS/AS&PC	Dissertation
Hu (2017)	275	36	M	HS&ST	General universities	SS&PC	Journal
Shu (2017)	378	57	D&M	HS&ST&A&M	Double First-class	CS/PS/AS&PC	Dissertation
Wu et al. (2018)	409	NR	NR	NR	Double First-class&General	SS&PC	Journal
Meng and Zhao (2018)	677	49	D&M	M	211&General	SS&PC	Journal
Zhang (2018)	209	28	D&M	HS&ST&M	985&211&General	PS/AS&PC	Dissertation
Yao and Yu (2019)	445	52	D&M	NR	985	SS&PC	Journal
Zhu L.-L. (2019)	497	57	M	HS&ST	NR	CS/PS/AS&PC	Dissertation
Duan (2019)	178	57	M	HS	Double First-class&General	CS/PS/AS/SS&PC	Dissertation
Yang (2019)	216	5	M	M	NR	AS&PC	Dissertation
Zhu F.-Q. (2019)	305	34	M	HS&ST&M	985&211&General	SS&PC	Dissertation
Du (2019)	2,313	62	D	HS&ST	985&211&General	SS&PC	Journal
Wu and Luo (2020)	1,418	NR	D	NR	985&211&General	CS&PC	Journal
Yang (2020)	400	33	D&M	HS&ST	Double First-class	CS/PS/AS/SS&PC	Dissertation
Zhang (2020)	260	46	M	HS&ST	985&211&General	SS&PC	Dissertation
Shang (2020)	509	51	M	HS&ST	NR	SS&PC	Dissertation
Li and Shu (2020)	2,313	NR	D	HS&ST&M	985&211&General	SS&PC	Journal
Feng et al. (2020)	440	64	D	ST	NR	SS&PC	Journal
Liu (2021)	327	49	M	HS&ST	General	CS/PS/AS/SS&PC	Dissertation
Qian (2021)	466	NR	D&M	HS&ST	NR	SS&PC	Dissertation
Zhang (2021a)	390	58	M	ST	General	CS/PS/AS/SS&PC	Dissertation
Xu (2021)	301	23	M	HS&ST&A&M	General	SS&PC	Dissertation
Li et al. (2021)	1,007	43	D&M	A	NR	SS&PC	Journal
Zhao (2021)	322	46	M	HS&ST&A&M	NR	CS/PS/AS&PC	Dissertation
Zhang (2021b)	345	47	M	HS&ST	NR	CS/PS/AS&PC	Dissertation
Zhang (2021c)	418	40	M	HS&ST	Double First-class&General	SS&PC	Dissertation
Jiang et al. (2021)	445	43	D&M	M	NR	SS&PC	Journal
Su et al. (2021)	601	42	D&M	HS&ST&A&M	NR	PS/AS&PC	Journal
Zhang B.-S. et al. (2021)	207	25	NR	HS&ST&M	NR	PS/AS&PC	Journal
Xiao et al. (2021)	2,024	NR	M	NR	NR	SS&PC	Journal
Liu Y.-Y. (2022)	413	46	M	HS&ST	Double First-class&General	SS&PC	Dissertation
Xu (2022)	451	54	D&M	NR	985	AS&PC	Journal
Zhang et al. (2022b)	1,108	56	NR	ST	Double First-class	AS&PC	Journal

(Continued)

TABLE 1 (Continued)

Author (year)	N	Male (%)	Degree ^a	Discipline ^b	HEI type ^c	Variable ^d	Literature type
Wang and Cai (2022)	4,521	NR	D	HS&ST	Double First-class	SS&PC	Journal
Zhang et al. (2022c)	728	32	D&M	NR	Double First-class&General	SS&PC	Journal
Han et al. (2022)	996	36	D&M	HS&ST&M	NR	CS/PS/AS&PC	Journal
Zhang et al. (2022a)	888	52	D&M	HS	985&211&General	SS&PC	Journal
Shen (2022)	466	49	M	HS&ST	Double First-class&General	CS/PS/AS/SS&PC	Dissertation
Xiang (2022)	929	44	M	HS&ST&A&M	Double First-class&General	CS/PS/AS&PC	Dissertation
Wu (2023)	224	NR	D	HS	Double First-class	SS&PC	Journal
Qiao (2023)	387	38	M	HS&ST&A&M	Double First-class&General	CS/PS/AS/SS&PC	Dissertation
Lv (2023a)	322	NR	NR	HS	NR	SS&PC	conference paper
Chen et al. (2023)	445	43	M	M	General	SS&PC	Journal
Peng (2023)	926	52	M	HS&ST&A&M	NR	SS&PC	Journal
Zhao (2023)	517	54	M	HS	NR	CS/PS/AS/SS&PC	Dissertation
Lv (2023b)	504	49	M	HS&ST	Double First-class	CS/PS/SS&PC	Dissertation
He and Zhu (2023)	981	49	D	HS&ST&A&M	NR	CS/PS/AS&PC	Journal
Li (2023)	898	41	M	HS&ST	NR	SS&PC	Dissertation
Zhang et al. (2023)	347	47	D&M	HS&ST	Double First-class&General	SS&PC	Journal
Yao (2023)	1,092	45	M	HS&ST	Double First-class&General	CS/PS/AS/SS&PC	Dissertation
Wang et al. (2023)	2,306	56	D	HS&ST	Double First-class	CS/AS&PC	Journal
Yang (2024)	584	33	M	HS&ST&A&M	Double First-class&General	CS/PS/AS/SS&PC	Dissertation
Mo et al. (2024)	404	26	M	M	NR	SS&PC	Journal
Zhai et al. (2024)	391	NR	M	NR	NR	SS&PC	Journal

^aM, master's students; D, doctoral students; NR, not reported.

^bNR, not reported; HS, Humanities and Social Sciences; ST, Science and Technology; A, Agricultural Science; M, Medical Sciences.

^cHEI, higher education institution; NR, not reported; 211, Universities belonging to "Project 211"; 985, Universities belonging to "Project 985"; "Double First-class," world-class construction university and first-class disciplines construction university; General, other university.

^dCS, academic support; PS, personal support; AS, autonomy support; SS, supervisor support; PC, postgraduate creativity.

k is the number of effects) indicated controlled publication bias (Rothstein et al., 2005), whereas significant Egger's test results ($p < 0.05$) suggested publication bias (Egger et al., 1997). Based on the observed heterogeneity, subgroup and meta-regression analyses were conducted to explore potential moderating variables.

3 Results

This meta-analysis included 62 documents: 32 journal articles, 29 dissertations, and one conference paper. These documents contained 111 effect sizes and data points from 51,640 graduate students.

3.1 Heterogeneity test and publication bias

As shown in Table 2, the Q values for supervisor support and its subtypes, as well as postgraduate creativity, were all significant at the 0.001 level, indicating heterogeneity in effect sizes. Additionally, the I^2 values were all >75%, indicating a high degree of heterogeneity across studies. This suggests the presence

of potential moderating variables between supervisory support and postgraduate creativity. To test whether the results were biased due to effect sizes from different sources, this study first used the fail-safe number (Nfs). The Nfs values for CS, PS, AS, and SS were 6,113, 2,979, 6,229, and 18,628, respectively, all exceeding their critical values of 115, 120, 135, and 225 ($5k + 10$), indicating that publication bias was effectively controlled. On this basis, we further used conducted Egger's t -test. The results were 1.02 ($p > 0.05$), 0.89 ($p > 0.05$), 1.21 ($p > 0.05$), and 0.93 ($p > 0.05$), indicating no statistically significant bias. Therefore, the publication bias in this meta-analysis was negligible.

3.2 Main effects test

To examine the relationship between supervisor support and postgraduate creativity, we calculated the correlation coefficient (r) between the two. According to Gignac and Szodorai's (2016) classification of correlation coefficients (low: $r = 0.10$; medium: $r = 0.30$; high: $r = 0.50$), academic support ($r = 0.466$), personal support ($r = 0.432$), autonomy support ($r = 0.426$), and supervisor support ($r = 0.474$) significantly contributed to graduate

student creativity, showing positive correlations with medium to high strength.

3.3 Moderating effects test

This study examines the moderating effects of four variables: gender, degree, discipline, and type of higher education institution. gender, treated as a continuous variable (Wu and Fu, 2024), was analyzed using meta-regression, whereas other categorical variables were analyzed using subgroup analyses. The results of the meta-regression analyses indicated that the moderating effect of gender on academic support ($Beta = -0.062, p = 0.665$),

personal support ($Beta = -0.116, p = 0.301$), autonomy support ($Beta = -0.003, p = 0.974$), and supervisor support ($Beta = 0.060, p = 0.525$) was not significant ($p > 0.05$). This finding suggests that gender does not moderate the relationship between supervisor support and postgraduate creativity. The results of the subgroup analyses revealed the following: First, degree significantly influenced academic support ($Q_B = 6.381, p = 0.012$), personal support ($Q_B = 11.191, p = 0.001$), and autonomy support ($Q_B = 5.990, p = 0.014$). Academic support, personal support, and autonomy support were all more strongly correlated with the creativity of master’s students than with doctoral students (Table 3). Supervisor support was most strongly associated with postgraduate creativity in science and technology ($r = 0.826, p < 0.001$), followed by humanities and social sciences, and medicine. Agricultural students showed the weakest correlation between creativity and supervisory support ($r = 0.434, p < 0.001$). Third, type of higher education institution significantly affected the relationship between supervisor support and postgraduate creativity ($Q_B = 14.842, p < 0.01$). Postgraduate creativity in general universities was most influenced by supervisor support ($r = 0.540, p < 0.001$) (Table 4).

TABLE 2 Random effects model of supervisor support and postgraduate creativity.

Variable relationships	k	r	95%CI		Q _W	I ²
			Lower	Upper		
CS&PC	21	0.466	0.344	0.573	1,465.186	98.635***
PS&PC	22	0.432	0.339	0.516	682.762	96.924***
AS&PC	25	0.426	0.340	0.505	864.697	97.224***
SS&PC	43	0.474	0.408	0.536	2,688.601	98.438***

k is the number of effects; r is the correlation coefficient; 95% CI is the 95% confidence interval of r; Q_w is the test statistic for within-group heterogeneity; ***p < 0.001; and I² values were interpreted using the following thresholds: 25%, low heterogeneity; 50%, moderate heterogeneity; and 75%, high heterogeneity (Wu and Fu, 2024).

4 Discussion and conclusion

This study employed a meta-analysis to synthesize the results of 62 empirical studies involving Chinese graduate students. The findings indicate that (1) supervisor support and its sub-types—academic support, personal support, and autonomy support—are

TABLE 3 Results of a meta-analysis of the moderating effect of degree type.

Variable	Degree	Heterogeneity			k	r	95%CI	
		Q _B	df	p			Lower	Upper
CS	Master	6.381	1	0.012	14	0.509	0.353	0.638
	Doctor				4	0.377	0.101	0.377
PS	Master	11.191	1	0.001	14	0.446	0.338	0.542
	Doctor				2	0.167	0.038	0.290
AS	Master	5.990	1	0.014	14	0.451	0.334	0.555
	Doctor				3	0.233	0.095	0.363

Q_B is the test statistic for heterogeneity between groups.

TABLE 4 Results of a meta-analysis of the moderating effect of discipline and HEI type.

Variable	Moderator variable	Type	Heterogeneity			k	r	95%CI	
			Q _B	df	p			Lower	Upper
SS	Discipline	HS	147.372	3	0.000	5	0.575	0.279	0.772
		ST				1	0.826	0.792	0.855
		M				4	0.545	0.486	0.550
		A				1	0.434	0.382	0.438
	HEI	211	14.842	3	0.002	1	0.437	0.322	0.540
		985				1	0.207	0.116	0.294
		Double first-class				6	0.422	0.249	0.569
		General				5	0.540	0.284	0.723

significantly and positively associated with postgraduate creativity. (2) The relationship between academic support, personal support, autonomy support, and postgraduate creativity was moderated by degree level, with supervisor support behaviors showing a stronger correlation with creativity at the master's level than at the doctoral level. (3) Discipline and type of higher education institution also influence the relationship between supervisor support and postgraduate creativity, while the moderating effect of gender was not significant. Building on the aforementioned conclusions, this study offers targeted recommendations to foster creativity among postgraduate students.

4.1 The significant correlation between supervisor support and postgraduate creativity

A significant positive correlation exists between supervisor support, its subtypes, and postgraduate creativity, aligning with the findings of Wang et al. (2013), Wu et al. (2014), Han et al. (2022), and Xu (2022). From an organizational behavioral perspective, supervisors play a crucial role in graduate students' creativity by affecting individual factors (Meng and Zhao, 2018). As the number of postgraduate students in China exceeds the number of supervisors, the current system relies predominantly on a single supervisor model (Jibao et al., 2015). Consequently, the development of postgraduate creativity depends heavily on supervisors (Peng, 2019), underscoring the medium to high strength of the positive correlation between supervisor support and postgraduate creativity. Specifically, in terms of academic support, supervisors' academic capital—such as their reputation, social resources, published research, teaching experience, and academic networks—provides postgraduate students with increased opportunities to engage in innovative activities, enhance their practical and problem-solving skills, and enrich their personal growth (Zhang et al., 2022a). Supervisors who offer emotional support and maintain friendly attitudes are more likely to foster free and open research environments (Wang et al., 2013). This environment not only stimulates postgraduate students' enthusiasm for engaging in innovative activities (Ruzek et al., 2016), but also encourages them to face difficulties and challenges with greater resilience (Han et al., 2022). Regarding autonomy support, supervisors who demonstrate appropriate interest and respect can satisfy students' basic psychological needs and elicit positive emotions in postgraduates by fostering a free and open cognitive environment (Guo et al., 2018). When postgraduates perceive autonomy support from their supervisors, they are more inclined to proactively communicate their innovative ideas and challenges, which further enhances their autonomy in the collection, generation, and implementation of innovative ideas (Zhang et al., 2022b).

4.2 Gender has no moderating effect

Although some studies suggest that women, being generally more sensitive to interpersonal relationships, may be deterred

from engaging in innovative activities with a positive mindset if they perceive neglect or rejection from their supervisors (Fan and Jiang, 2025), when women perceive supervisor support, they are more likely to actively engage in and advance their research (Conrad, 2017). Moreover, gender stereotypes often label female postgraduates as “sensitive” or “fragile,” prompting supervisors to exercise greater caution in guiding them. This dynamic can create communication barriers that hinder the quality of guidance (Sun and Zhang, 2020). However, the findings of this study indicate that gender does not significantly moderate the relationship between supervisor support and postgraduate creativity. This may be explained in two ways. First, gender differences may not be substantial enough to influence perceptions of supervisor support among graduate students. The relationship between Chinese supervisors and graduate students is primarily hierarchical and characterized by supervisory authority rather than clear employment or collaborative dynamics (Zhang et al., 2022a). In this context, a high level of supervisory support may mitigate the effect of gender differences on graduate students' perceptions (Platow, 2012). Second, the studies included in the meta-analysis may have had a relatively balanced distribution of male and female participants, which could have obscured any potential sex effects and prevented them from reaching statistical significance.

4.3 Degree, discipline, and type of higher education institution have a moderating effect

First, the moderating effect of the degree on the relationship between academic support, personal support, autonomy support, and postgraduate creativity was significant. The correlation was notably higher at the master's level than at the doctoral level, indicating that master's degree students are more reliant on their supervisors' supportive behaviors. This finding aligns with that of Ouyang and Hu (2020). China's doctoral training system primarily selects candidates based on their research output (Zhang, 2024). Doctoral students are required to publish a specified number of academic works to demonstrate their academic competence, which places them under significant pressure. Consequently, they must enhance their personal initiative to improve self-management (Flynn et al., 2012) and drive their academic development through academic expectations, self-regulation, and intrinsic motivation (Gardner, 2010). Conversely, master's students, who often have less developed research skills, lower research interest, higher employment pressures, and shorter training periods (Peng and Hu, 2021), require more comprehensive guidance and support from supervisors to effectively commit to their research and enhance their academic performance (Zhang X. et al., 2021).

Second, the moderating effect of discipline on the relationship between supervisor support and postgraduate creativity was significant, aligning with the findings of Zheng et al. (2022) and Pan and Gu (2022). Specifically, the strongest correlation between supervisor support and postgraduate creativity was observed in the fields of science and engineering. As “hard

applied disciplines,” these fields require postgraduates to engage in and complete major research projects to produce scientific output. Moreover, they demand substantial academic resources to overcome challenges in scientific research (Gu and Lin, 2011). Additionally, a supervisor’s theoretical knowledge, research experience, and understanding of disciplinary frontiers are essential for postgraduates to achieve innovative research outcomes (Min and Li, 2018). In contrast, research in the humanities and social sciences often involves philosophical discourse and communicative insights (Zheng et al., 2022). As a result, interactions between supervisors and postgraduates serve as the primary means of guiding students’ cognitive development, encouraging academic exploration, and stimulating creative enthusiasm (Qin and Li, 2023). In these fields, the development of postgraduate creativity relies more heavily on the time spent with supervisors. The correlation between supervisor support and postgraduate creativity in the medical field is relatively weak. One possible explanation is that medical supervisors often fulfill dual roles as both educators and clinical practitioners, limiting their time and energy and leading them to prioritize solving experimental and clinical practice issues over fostering postgraduate creativity (Pan and Gu, 2022). Additionally, postgraduate students undergoing hospital-based standardized training receive limited guidance from their supervisors (Cai and Chen, 2024). In agricultural studies, postgraduate training in China primarily adheres to the traditional “master-apprentice” model (Qi et al., 2019). However, the significant imbalance in the supervisor-to-student ratio, driven by the expansion of higher education enrollment, has made it challenging for postgraduate students to receive adequate supervision (Zhang et al., 2011).

Third, the type of higher education institution significantly moderates the relationship between supervisor support and postgraduate creativity. The correlation between supervisor support and postgraduate creativity is stronger in general universities than in key construction universities. For decades, China’s higher education system has followed an uneven development policy (Liu, 2024), prioritizing universities under the 211 and 985 Projects and, more recently, the “Double First-Class” initiative in resource allocation. This has resulted in a binary structure within China’s higher education system, distinguishing key construction universities from general universities (Liu, 2025). High-quality resources are disproportionately allocated to key construction universities, enabling graduate students in these institutions to enhance their knowledge acquisition and research skills not only through their supervisors but also through a comprehensive curriculum and extensive platform resources (Liu and Wang, 2020). Moreover, key construction universities, given their responsibility for national key projects and cutting-edge scientific research, place strong emphasis on selecting top students during the admissions process (Ye et al., 2024). The higher qualifications of students suggest that graduate students at key construction universities generally possess a strong professional foundation, clearer goals, greater research potential, and a heightened sense of personal initiative and self-efficacy (Cai et al., 2023). Consequently, compared to their counterparts at general

universities, who rely more on supervisor support and oversight, graduate students at key construction universities are more likely to take an active role in advancing scientific research and innovation.

4.4 Recommendations for strengthening supervisor support to enhance postgraduate creativity

Postgraduate creativity refers to graduate students’ willingness to seek knowledge and explore new ideas, as well as their ability to generate innovative concepts, apply novel methods, create original work, and solve complex problems by integrating knowledge and experience (Wang et al., 2022). Essentially, fostering postgraduate creativity involves guiding students in critical thinking (Bosch, 2018), enabling them to identify, analyze, and resolve problems creatively. A meta-analysis of 51,640 Chinese graduate students found that academic, personal, and autonomy support from supervisors positively influence postgraduate creativity. Additionally, degree level, discipline, and the type of higher education institution moderate the relationship between supervisor support and postgraduate creativity. Based on these findings, supervisors can enhance their guidance in the following areas. First, supervisors should offer sufficient resources to support postgraduate research and innovation, including research experience, financial assistance, and social networks (Zhao and Jiang, 2020). This enables students to access academic resources, receive guidance from experts, and participate in academic seminars (Zhang et al., 2022a), facilitating the smooth progression of innovation activities while expanding their research horizons. Second, according to social influence theory, when the mentee perceives the mentor’s trust, the mentor-mentee relationship tends to develop in a positive direction (He and Zhu, 2023). Therefore, from an individual support perspective, supervisors should focus on providing psychological support to reduce students’ mental pressure and burdens during the innovation process (Wang et al., 2013), encouraging them to face challenges and failures in research and innovation. Third, the postgraduate stage is a critical transition from student to scholar (He and Zhu, 2023), with independent research and innovation serving as key indicators of this progression. Therefore, supervisors should adopt an egalitarian and democratic approach in academic exchanges to enhance their guidance (Zhao and Jiang, 2020), fostering independent exploration and critical thinking among students. Fourth, variations in the training objectives of master’s and doctoral programs, disciplinary characteristics, and institutional types necessitate differentiated supervisory strategies tailored to the training stage, discipline, and institutional context (Huang, 2014) to optimize mentoring outcomes. In other words, supervisors should adjust the level of academic, personal, and autonomy support based on specific circumstances.

Author contributions

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