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Impact of academic title structure of university research teams on research output: evidence from 30 Chinese universities

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Despite widespread agreement in the scholarly community about the significance of academic title structure on research output, research on the underlying mechanisms remains insufficient. Social contribution and research resources were selected as mediating variables, panel data of the materials science and engineering discipline of 30 Chinese universities from 2016 to 2020 were chosen as the research samples, and a fixed-effects model was subsequently applied to conduct a chain mediating effect test. The results showed: (1) Both the proportion of national-level talents and that of senior titles can promote research output, with the former having a much greater effect, while the proportion of associate senior titles has an indistinctive negative correlation with research output. (2) Both the proportion of national-level talents and that of senior titles can significantly enhance research output through the chain mediating effect of social contribution and research resources, with national-level talents having a stronger ability to make social contributions and obtain research resources. (3) Social contribution is more effective than research resources in enhancing research output. Based on the findings, it is recommended to improve policies for introducing high-end talents and to increase support for researchers with associate senior titles. Furthermore, it is advisable to establish a research evaluation system based on social influence, guiding researchers to obtain research resources and enhance research output through social contributions.

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Introduction

To seize the opportunities of the new round of technological revolution and industrial transformation, China has formulated and implemented the innovation-driven development strategy, setting three milestone goals: to join the ranks of innovative countries by 2020, to be among the forefront of innovative countries by 2030, and to become a world-leading power in science and technology innovation and a major global center for science and innovation by 2050 (Bo, 2019). Against the backdrop of China's unprecedented emphasis on scientific and technological innovation, the research output of universities should be highly valued, as the higher education institutions are the main battleground for innovation. Studies on the factors influencing research output have shown that academic titles contribute significantly more to researchers' output than other factors such as salary, research investment time, and research collaboration (Zhang and Shen, 2019; Gu and Shen, 2012). These studies provide a theoretical basis for this paper to focus on the impact of academic title structure on research output.

The research on the relationship between academic title and research output can be roughly divided into three categories: the first category is to study the impact of academic title on scientific research output from the perspective of individual researchers, revealing a positive relationship between academic titles and the quantity and quality of research output (Huang, 2021; Fulton and Trow, 1974). Notably, scholars with senior titles are more productive in research papers (Wei et al., 2018). The second category is the influence investigation of academic title structure from the perspective of university management on scientific research output. These studies focus on the relationship between the proportion of different academic titles and university development, suggesting that university research output and development are influenced by the structure of academic titles (You et al., 2017; Ding and He, 2021; Cai and Ren, 2017). The third category is to explore the function mechanism of academic title on scientific research output. These studies concentrate on the mediating role of research resources such as research funding and projects. It is believed that senior titled scholars, due to their possession of substantial human and social capital, can attract abundant external resources like research topics and funding for the university, which are crucial for the university survival and development (Thomas, 2010). Therefore, an important consideration in the appointment of professors in American universities is the ability to obtain resources from the government and the business sector (Derek, 2015). It is also found that research resources tend to flow towards renowned scientists (Merton, 1968), and when the proportion of senior and associate senior titles reaches a certain level, research resources such as the number of projects and research funding can reach a theoretical optimal level, thereby affecting research output (Chen and Yang, 2022). Existing literatures provide strong support for this study, but research on the function mechanism of academic title structure on research output still needs to be deepened. Current literatures mostly explore the single pathway of research resources, which is far from sufficient. In fact, a large number of literatures have analyzed the significance of social contribution to university development (Xia et al., 2022; Qi, 2022; Wang, 2018; Kim, Seok (2016); Liu, 2015), suggesting that universities must prove their value through social contributions in order to obtain development resources (Zhou and Zhi, 2009). Although these studies are not directly related to academic title structure and research output, and mostly lack the empirical data, they still provide inspirations for this study, suggesting that social contribution may play both an independent mediating role and a chain mediating role through research resources in the impact of academic title structure on research output. The

potential dual-role of social contribution merits further detailed investigation.

In light of this, this paper refers to existing research (Wang and Lou, 2020), measures social contribution by the number of scientific research awards at the provincial level and above, employs a fixed-effects model to test the chain mediating effect, and attempts to answer the following three specific questions: (1) What is the impact of the academic title structure on research output? (2) What is the function mechanism of academic title structure on research output? Is social contribution a function mechanism through which the academic title structure influences research output? If so, whether it plays an independent mediating role or a chain mediating role through research resources? (3) What are the differences in the impacts of diverse academic titles on research output? To accurately answer these questions, this study selects panel data from the materials science and engineering disciplines of 30 Chinese universities for empirical analysis. The main reason for choosing these 30 universities is that they all prioritize scientific research over teaching, making them suitable for addressing the research questions of this paper. Chinese higher education institutions include universities, colleges, and higher vocational and technical colleges. Among them, colleges focus on general education, and higher vocational colleges emphasize training in operational skills. In contrast to colleges and higher vocational colleges, which relatively focus more on teaching, the distinct characteristic of universities is their greater emphasis on scientific research. Furthermore, the materials science disciplines of all 30 Chinese universities in this study include national-level research talents in their academic title structures, ensuring comparability.

Overview of academic titles, social contributions, and research output of the study sample

Academic titles. As can be seen in Fig. 1, the total number of associate senior titles was slightly higher than that of senior titles throughout the study period, both of which were almost 3 times more than the total number of national-level talents. Moreover, the growth rate of both senior and associate senior titles was greater than that of national-level talents. Overall, the numbers of national-level talents, senior titles, and associate senior titles all showed steady growth, which reflects the motivational role of academic titles for researchers to some extent.

Social contribution. From Fig. 2, it can be observed that the social contribution (the number of scientific research awards at the provincial level and above) during the study period was not optimistic. In terms of quantity, the largest number of awards was

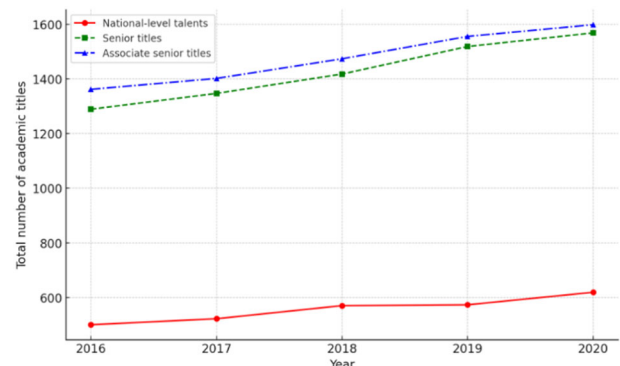


Fig. 1 National-level talents, senior titles, and associate senior titles from 2016 to 2020.

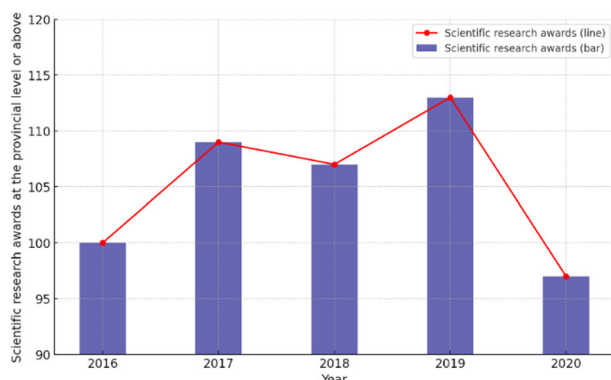


Fig. 2 Provincial-level and above research awards from 2016 to 2020.

achieved at 2019, scoring the number of 109, while there were 3648 academic titles holding the associate senior title and above in 2019, resulting in the number of awards per capita is less than 0.03. In term of trend, the number of scientific research awards has significantly declined after 2019. Scientific research awards represent the creative contributions of researchers to the economy and society (Wang and Lou, 2020), but their importance seems to be severely overlooked, which intensifies the necessity of this study.

Research output. This study uses the number of SCI papers published to evaluate research output, following the practice of the previous study (Zhang et al., 2015). As shown in Fig. 3, the quantity of research output has steadily increased during the study period, reflecting the research responsibilities of universities in the new era. However, the growth rate of research output is not high. So, there is an urgent need to further explore the pathways for researchers to enhance output, in order to better adapt to the requirements of the innovation-driven development strategy for university research.

Theoretical analysis and research hypotheses

A rational academic title structure can positively enhance the research output of universities (Ding and He, 2021). On the one hand, the primary consideration for the selection of top talents and the evaluation of titles is research capability, in other words, talent titles and senior titles represent higher research output. On the other hand, top talents have completed a higher degree of knowledge innovation and research accumulation in specific research fields, which can enhance the research productivity of their teams. Bland et al. (2006) three-factor model suggests that the academic ability of research team leaders not only directly affects the research output of team members but also drives their research output by fostering research environment and atmosphere. Azoulay et al. (2010) found that after the death of an academic “superstar”, the publication rate of their team collaborators would on average continue to decline by 5–8%. It was also reported that senior titles have an absolute leading role in the quantity of research output (Liang et al., 2015). Accordingly, the first hypothesis of this study is proposed:

Hypothesis 1: the promotion of academic title structure on research output decreases in the following order: national-level talent proportion > senior title proportion > associate senior title proportion.

The production of high-quality research outcomes not only call for subjective factors such as self-discipline, research interest, and research capability of scholars but also require research resources such as project funding. Jacob and Lefgren (2011) found that research output of funded scholars increased by 20% in the

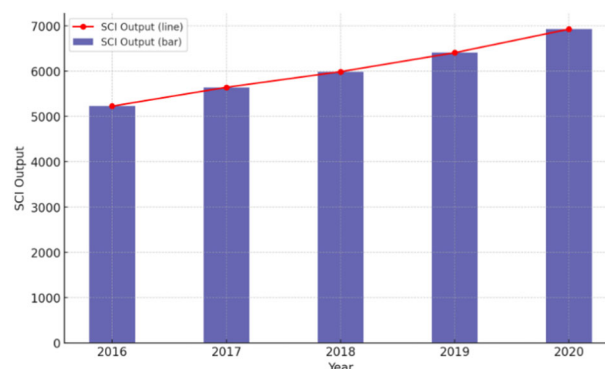


Fig. 3 The SCI papers published from 2016 to 2020.

following five years. Wang (2018) found that commercial R&D funding in American universities had a significant positive impact on research output. Meanwhile, the acquisition of research resources is also influenced by academic titles. Merton (1968) proposed the Matthew effect in science, suggesting that research resources often flow to scientists who have already proven their capabilities, and the more renowned the researchers are, the more advantages in research resources they can acquire. Based on the above analysis, the second hypothesis of this study is proposed:

Hypothesis 2: research resources play an independent mediating role between academic title structure and research output.

The fundamental reason why the acquisition of research resources is influenced by academic titles lies in the different levels of social contributions made by researchers at different levels of academic titles. Typically, The higher the academic title of researchers, the greater their social contribution. Social contribution is a way for researchers to demonstrate their value to the external community. Only when the external community recognizes the value of researchers will it provide them with the research resources (Zhou and Zhi, 2009). That is to say, social contribution can lead to an increase in research resources. At the same time, the social contributions of researchers mean that they have creatively solved problems encountered in human production and life. In other words, social contributions can also lead to the generation of new knowledge. Based on the above analysis, the following hypotheses are proposed:

Hypothesis 3: social contribution plays an independent mediating role between academic title structure and research output.

Hypothesis 4: social contribution and research resources play a chain mediating role between academic title structure and research output.

Research design

Sample and data. The data for this study was collected from a survey of materials science and engineering disciplines in 30 Chinese universities, all of which could grant master and doctor degrees in the first-level discipline of materials science and engineering¹ (hereafter referred to as “materials discipline”). The reason for choosing the materials discipline as the research subject is due to its strong applicability and close connection with social production and life, which makes its social contribution more pronounced and highly applicable to this study. Therefore, selecting it as the research object is highly representative and referential. To explore the function mechanism of academic title structure on university research output, the number of academic titles at different levels, social contributions, research resources, and research output in the materials disciplines of the surveyed universities from 2016 to 2020 were collected. The survey was conducted from April to June 2022, lasting 3 months, and five years of balanced panel data were collected.

Variables

Dependent variable. The dependent variable in this study is research output. Most of studies use the number of papers to measure it (Xie and Shauman, 1998). Therefore, following the practice of the previous study (Zhang et al., 2015), the number of SCI papers published is used to measure research output.

Independent variable. The independent variable in this study is the academic title structure, mainly referring to the proportion of top talents and various academic titles in universities. The scope of the academic title in this study is the associate senior title and above, including national-level talents. Therefore, the title structure is measured by the proportion of national-level talents, senior titles, and associate senior titles in the total number of full-time teachers.

Mediating variable. Social contribution and research resources are chosen as mediating variables. (1) Social contribution. It is suggested that scientific awards represent the creative contributions of researchers to the economy and society (Wang and Lou, 2020). Based on the availability of data, the total number of national research awards, Outstanding Scientific Research Achievement Awards from the Chinese Ministry of Education and provincial research awards are used to represent the social contribution. The number of national research awards refers to the total of the National Natural Science Awards, the National Technological Invention Awards, and the National Science and Technology Progress Awards. (2) Research resources. Research platforms, projects, and funding are important research resources (Chen, 2023; Zhao et al., 2023; Chen and Yang, 2022). Therefore, indicators from three dimensions are selected to measure research resources: the number of research platforms at the provincial level and above, the number of projects funded by the National Natural Science Foundation of China (NSFC), and the annual research funds received. Inspired by the method of Liu and Chen (2023), the weights of the three dimensions are assigned using the equal-weight method, and a weighted average is subsequently computed to derive the assessment of research resources.

Control variables. Existing researches have shown that the level of the university, the province in which the university is located, the number of postgraduates, and the total number of full-time teachers (Chen and Yang, 2022; Liang et al., 2021) are all important factors affecting research output. Therefore, the level of the university, the province in which the university is located, the number of postgraduates, and the total number of full-time teachers are included as control variables in the model. Among them, the level of the university and the province in which the university is located are dummy variables, based on “whether it belongs to ‘Project 211’ or ‘Project 985’”, with 1 assigned if so, or with 0 assigned if not. The same assignment is made for “whether it is located in the Beijing-Shanghai-Guangzhou”, with 1 assigned if so, or with 0 assigned if not. Meanwhile, in order to mitigate validity issues arising from multicollinearity, the quantities of postgraduates and the number of full-time teachers are log-transformed prior to incorporation into the model. The descriptive statistics results of the relevant data are shown in Table 1.

Research method

Econometric model. A fixed-effects model is employed to test the chain mediating effect. Since the development plans of Chinese universities generally follow the same institutional system and value norms, and they often emulate each other in their operating models, leading to less pronounced individual differences in

aspects such as campus culture and research atmosphere. Instead, the economic development status of the province where a university is located, and whether the university is classified as “Project 211” or “Project 985” have significant impact on the received development funds and policy support. Therefore, the fixed-effects model in this study refers to year-fixed effects, province fixed effects, and university level fixed effects.

The steps for testing the chain mediating effect. The chain mediating effect is a type of multiple mediating effect, where multiple mediating variables influence each other, exhibiting sequential characteristics, and forming a mediating chain. According to the sequential testing method proposed by Wen and Ye (2014), the steps for testing the chain mediating effect are as follows:

$$Y = cX + e_1 \quad (1)$$

$$M_1 = a_1X + e_2 \quad (2)$$

$$M_2 = a_2X + d_1M_1 + e_3 \quad (3)$$

$$Y = c'X + b_1M_1 + b_2M_2 + e_4 \quad (4)$$

In the equations above, the coefficient c represents the total effect of the independent variable X on the dependent variable Y , c' represents the direct effect of X on Y , and M_1 and M_2 are the two mediating variables. The conditions that should be satisfied at each step are as follows:

Step 1: perform regression on Eq. (1) and test whether the coefficient c is statistically significant. If the coefficient c is significant, proceed to Step 2; if the coefficient c is insignificant, the test should be terminated.

Step 2: sequentially test the coefficient a_1 in Eq. (2) and the coefficient b_1 in Eq. (4). If the both are significant, it indicates that at least part of the effect of the independent variable X on the dependent variable Y is realized through M_1 , the mediating effect is established, and the indirect effect should be reported as $a_1 \times b_1$. Sequentially test the coefficient a_2 in Eq. (3) and the coefficient b_2 in Eq. (4). If the both are significant, it indicates that at least part of the effect of the independent variable X on the dependent variable Y is realized through M_2 , the mediating effect is established, and the indirect effect should be reported as $a_2 \times b_2$. Test the coefficient d_1 in Eq. (3). If it is significant, the chain indirect effect of M_1 and M_2 is significant, and the indirect effect should be reported as $a_1 \times d_1 \times b_2$.

Step 3: compare the coefficient c' in Eq. (4) with the coefficient c in Eq. (1). If they have the same sign and c' is significant, it indicates that only part of the effect of the independent variable X on the dependent variable Y is realized through the mediating paths of M_1 and M_2 , so there is a partial mediating effect. If c' is insignificant, it indicates that the entire effect of X on Y is realized through the mediating paths of M_1 and M_2 , so there is a full mediating effect.

According to the above test steps and the research hypotheses hereinbefore, a theoretical model of the chain mediating effect of academic title structure on research output is built.

$$Out_{it} = c_1Tale_{it} + c_2Seni_{it} + c_3Asso_{it} + \sum control + \varepsilon_{it} \quad (5)$$

$$Cont_{it} = a_{11}Tale_{it} + a_{12}Seni_{it} + a_{13}Asso_{it} + \sum control + \varepsilon_{it} \quad (6)$$

$$Reso_{it} = a_{21}Tale_{it} + a_{22}Seni_{it} + a_{23}Asso_{it} + d_1Cont_{it} + \sum control + \varepsilon_{it} \quad (7)$$

$$Out_{it} = c_1'Tale_{it} + c_2'Seni_{it} + c_3'Asso_{it} + b_1Cont_{it} + b_2Reso_{it} + \sum control + \varepsilon_{it} \quad (8)$$

Table 1 Descriptive statistics.					
Variable	Sample Number	Mean	Standard Deviation	Min	Max
Number of national talents	150	18.56	18.46	0	108
Proportion of national talents	150	0.14	0.11	0	0.58
Number of senior titles	150	47.61	21.67	9	111
Proportion of senior titles	150	0.39	0.12	0.17	0.73
Number of associate senior titles	150	49.29	23.01	14	125
Proportion of associate senior titles	150	0.4	0.11	0.16	0.75
Number of SCI papers published	150	201.3	136.4	13	801
Number of projects funded by NSFC	150	18.81	14.7	0	85
Annual receivable scientific research fund (in billion yuan)	150	0.509	0.367	0.037	1.531
Number of research platforms	150	6.24	3.714	1	16
Number of national awards	150	0.19	0.5	0	3
Number of Outstanding Scientific Research Achievement Awards from the Chinese Ministry of Education	150	0.22	0.57	0	4
Number of provincial awards	150	3.1	3.41	0	23
Number of postgraduates	150	632.3	413	48	1967
Number of full-time teachers	150	124.1	50.28	50	296
Level of university	150	0.77	0.42	0	1
Province of university	150	0.23	0.42	0	1

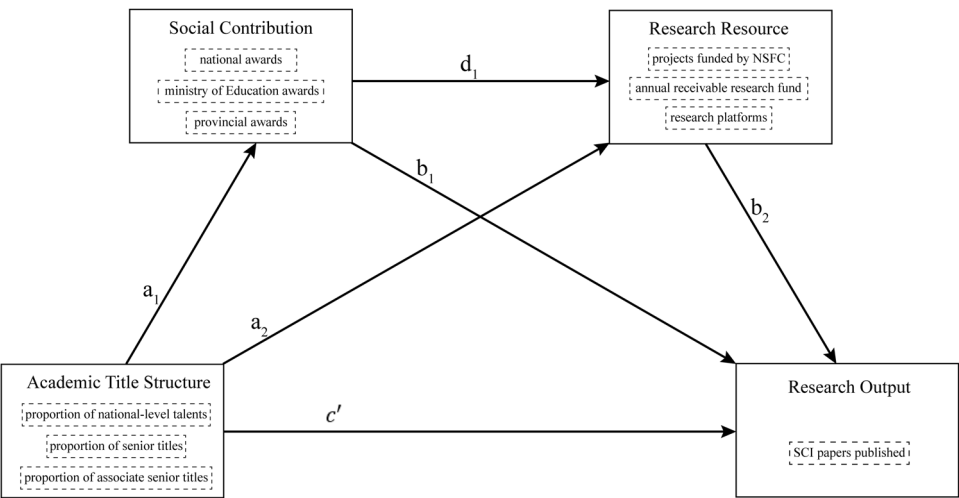


Fig. 4 The function mechanism of academic title structure on research output.

$$\sum control = lnPost_{it} + lnFul_{it} + Lev_{it} + Pro_{it} \tag{9}$$

total effect of academic title structure on research output
 $c = c' + a_1 \times b_1 + a_1 \times d_1 \times b_2 + a_2 \times b_2$.

Out_{it} represents the research output of university i 's materials discipline in year t . $Tale_{it}$, $Seni_{it}$, and $Asso_{it}$ respectively represent the proportions of national-level talents, senior titles, and associate senior titles in university i 's materials discipline in year t , $Cont_{it}$ represents the social contribution of university i 's materials discipline in year t , and $Reso_{it}$ represents the research resources of university i 's materials discipline in year t . Lev_{it} , Pro_{it} , $lnPost_{it}$, and $lnFul_{it}$ are four control variables, representing the level of university i , the province of university i , and the log-transformed numbers of postgraduates and full-time teachers in year t respectively. ε_{it} represents the random error term. In addition, year fixed effects, province fixed effects, and university level fixed effects are all included in the model. The function mechanism diagram of academic title structure on research output is depicted in Fig. 4.

As can be seen in Fig. 4, the independent mediating effects of social contribution and research resources are $a_1 \times b_1$ and $a_2 \times b_2$ respectively; the chain mediating effect is $a_1 \times d_1 \times b_2$, the direct effect of academic title structure on research output is c' , and the

Results

This study conducts regression analysis using Stata software, and the regression results are presented in Table 2.

In Table 2, Models (1–4) are the regression results of Eqs. (5–8), respectively. It can be seen that the total effect (430.20) and direct effect (292.78) of the proportion of national-level talents on research output are significant at the 1% level; the total effect (266.90) and direct effect (204.47) of the proportion of senior titles on research output are significant at the 1% and 5% levels, respectively; the total effect (−0.67) of the proportion of associate senior titles on research output is insignificant negative. It is evident that the promotion of academic title structure on research output decreases in the following order: national-level talent proportion > senior title proportion > associate senior title proportion, confirming the validity of Hypothesis 1.

Furthermore, based on the mediating effect test method proposed by Wen and Ye (2014), the test results of the mechanisms through which the proportions of associate senior titles, senior

Table 2 Test results of the function mechanism of academic title structure on research output.				
	Model (1) Research Output	Model (2) Social Contributions	Model (3) Research Resource	Model (4) Research Output
National Talent	430.20*** (5.43)	13.33*** (5.23)	11.09*** (3.30)	292.78*** (3.35)
Senior titles	266.90*** (3.25)	5.16* (1.95)	6.35* (1.97)	204.47** (2.50)
Associate senior titles	−0.67 (−0.01)	−3.05 (−1.38)	1.25 (0.46)	13.76 (0.20)
Social contributions			0.44*** (4.25)	4.60* (1.68)
Research resource				4.50** (2.11)
Postgraduate	40.57*** (3.51)	−0.38 (−1.03)	1.49*** (3.31)	36.38*** (3.12)
Full-time teachers	60.10*** (2.68)	2.24*** (3.11)	3.26*** (3.62)	30.72 (1.31)
Level of university	3.78 (0.19)	0.05 (0.08)	−0.004 (−0.00)	3.46 (0.18)
Province of university	58.0*** (3.06)	0.96 (1.58)	2.59*** (3.49)	40.01** (2.07)
_cons	−530.4*** (−5.01)	−7.63** (−2.24)	−22.81*** (−5.46)	−377.67*** (−3.28)
Year _t	controlled	controlled	controlled	controlled
Pro _i	controlled	controlled	controlled	controlled
Lev _i	controlled	controlled	controlled	controlled
N	150	150	150	150
R ²	0.6536	0.4449	0.6916	0.6795
adj. R ²	0.6260	0.4006	0.6646	0.6489
t statistics in parentheses *p < 0.1, **p < 0.05, ***p < 0.01				

titles, and national-level talents affect research output are separately analyzed:

First, in Model (1), the total effect of the proportion of associate senior titles on research output is not significant, which does not meet the condition for proceed of the next test step, thus, the chain mediating effect test is terminated.

Second, in Model (1), the total effect of the proportion of senior titles on research output (266.90) is significant positive at the 1% level. It is determined that the coefficient c in the first step of the chain mediating effect model is significant, meeting the verification condition of the next test step. In Models (2) and (4), the regression coefficient of the proportion of senior titles on social contribution (5.16) and the regression coefficient of social contribution on research output (4.60) are both significant positive at the 10% level, confirming that both a_1 and b_1 in the second step of the chain mediating effect model are significant; in Models (3) and (4), the regression coefficient of the proportion of senior titles on research resources (6.35) and the regression coefficient of research resources on research output (4.50) are significant positive at the 10% and 5% levels, respectively, indicating that both a_2 and b_2 in the second step of the chain mediating effect model are significant; in Model (3), the regression coefficient of social contribution on research resources (0.44) is significant positive at the 1% level, manifesting that d_1 in the second step of

the chain mediating effect model is significant. Comparing Models (1) and (4), the regression coefficients of the proportion of senior titles on research output (266.90 and 204.47) are both significant, confirming that c and c' in the third step of the chain mediating effect model are both positive and significant. It can be seen that the two mediating factors, which are social contribution and research resources, can play independent mediating roles and chain mediating role in the impact of senior titles on research output.

Third, in Model (1), the total effect of the proportion of national-level talents on research output (430.20) is significant positive at the 1% level. It can be concluded that the coefficient c in the first step of the chain mediating effect model is significant, meeting the verification condition of the next test step. In Models (2) and (4), the regression coefficient of the proportion of national-level talents on social contribution (13.33) and the regression coefficient of social contribution on research output (4.60) are significant positive at the 1% and 10% levels, respectively, indicating that both a_1 and b_1 in the second step of the chain mediating effect model are significant; in Models (3) and (4), the regression coefficient of the proportion of national-level talents on research resources (11.09) and the regression coefficient of research resources on research output (4.50) are significant positive at the 1% and 5% levels, respectively, confirming that both a_2 and b_2 in the second step of the chain mediating effect model are significant; in Model (3), the regression coefficient of social contribution on research resources (0.44) is significant positive at the 1% level, manifesting that d_1 in the second step of the chain mediating effect model is significant. Comparing Models (1) and (4), the regression coefficients of the proportion of national-level talents on research output (430.20 and 292.78) are both significant at the 1% level, confirming that c and c' in the third step of the chain mediating effect model are both positive and significant. It can be seen that the two mediating factors, which are social contribution and research resources, can also both play independent mediating roles and a chain mediating role in the impact of national-level talents on research output.

In summary, although it is not possible to verify the hypotheses related to the mediating effect using the proportion of associate senior titles, Hypotheses 2, 3, and 4 of this study are all validated in the impact of the proportion of national-level talents and senior titles on research output. That is, the two mediating factors, which are social contribution and research resources, can both play independent mediating role and chain mediating role in the impact of national-level talents on research output.

To further conduct an in-depth analysis, the effect levels of each mediation pathway are sorted out. The results are shown in Table 3.

As can be seen from Table 3, in the impact of the proportion of national-level talents and senior titles on research output, the total indirect effects account for 31.99% and 23.43% of the total effects, respectively. This proportion is not negligible, indicating that the indirect roles of social contribution and research resources are significant and should not be overlooked.

To facilitate comparative analysis, the impact processes of the proportion of national-level talents and senior titles on research output are further decomposed. The details are presented in Table 4.

As can be seen from Table 4, the impact of the proportion of national-level talents on social contribution (13.33) is nearly three times more than that of the proportion of senior titles (5.16); the impact of the proportion of national-level talents on research resources (11.09) is nearly twice more than that of the proportion of senior titles (6.35). This indicates that the higher the proportion of top talents in a research team of university, the stronger its ability to make social contributions and obtain research resources.

Table 3 Effect levels of total, direct, and indirect effects.

Function Mechanism	National talents		Senior titles	
	Effect level	Proportion in total effects	Effect level	Proportion in total effects
Total effect: title→output	430.20	100%	266.90	100%
Direct effect: title→output	292.78	68.06%	204.47	76.61%
title→contributions→output	61.32	14.25%	23.74	8.89%
title→resource→output	49.91	11.60%	28.58	10.71%
title→contributions→resource→output	26.39	6.13%	10.22	3.83%
Total indirect effect	137.62	31.99%	62.54	23.43%

Table 4 Decomposition of the effect process.

Effect category	Effect Process	Effect level	
		National talents	Senior titles
Total effects	title→output	430.20***	266.90***
Direct effect	title→output	292.78***	204.47**
	title→contributions	13.33***	5.16*
	title→resource	11.09***	6.35*
Indirect effect	contributions→resource	0.44***	0.44***
	contributions→output	4.60*	4.60*
	resource→output	4.5**	4.5**

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Additionally, the impact of social contribution on research resources (0.44) is significant positive at the 1% level, indicating that social contribution can positively promote the acquisition of research resources. At the same time, the impact of social contribution on research output (4.60) is greater than that of research resources (4.50). It is suggested that researchers in universities should focus more on social contributions other than research resources, demonstrating their value by meeting the real and significant need of society, thereby obtaining research resources and enhancing research output.

Conclusion and discussion

To further explore the impact of the academic title structure on research output, social contribution and research resources are firstly selected as mediating variables through literature review. Based on this, panel data from the materials disciplines of 30 Chinese universities from 2016 to 2020 were chosen as the research sample, and a fixed-effects model was subsequently used to conduct a chain mediating effect test. The results showed: (1) Both the proportion of national-level talents and that of senior titles can promote research output, with the former having a much greater effect, while the proportion of associate senior titles has an indistinctive negative correlation with research output. (2) Both the proportion of national-level talents and that of senior titles can significantly enhance research output through the chain mediating effect of social contribution and research resources, with national-level talents having a stronger ability to make social contributions and obtain research resources. (3) Social contribution is more effective than research resources in enhancing research output. These findings can provide a basis for improving the research evaluation system and reforming the conferring of academic titles.

The conclusions of this study are corroborated by previous research. Liang et al. (2015) revealed that the research output of professors, associate professors, and lecturers decreases in sequence. Although their sample selection differs from that of this study, both exhibit the same trend: higher titles promote research

output more effectively than lower titles. And this trend has also been validated by Fulton and Trow (1974). Additionally, it is found in current study that the total effect of the proportion of associate senior titles on research output is insignificant negative. The study by Jin et al. (2022) provides support for the result. They found that associate professors are under the greatest pressure from quantitative assessments, and this heavy pressure distorts their academic production behavior. Regarding the role of social contribution, He (2010) posited that universities can enhance their scientific research level and technological innovation ability through serving society. Kim and Seok (2016) also believed that the social contributions of universities aid their development. These findings are in line with the conclusions of this study. In terms of the role of research resources, Ebadi and Schiffauerova (2016) argued that funding can affect research output. Gulbrandsem and Smeby (2005) found a high correlation between commercial funding and research output. Zhang et al. (2015) discovered that research groups funded by the National Natural Science Foundation of China have a significantly higher number of SCI publications than those funded by other sources. Wang et al. (2016) found that the Youth Fund significantly improves the research output of young researchers. Although the types of research resources focused on in these studies are different from those in this study, the general conclusions provide important support for strengthening the conclusions of this paper.

There are three important implications in current study: (1) It provides a basis for improving the research evaluation system and reforming the conferring of academic titles. The indirect effects of social contribution and research resources on research output are clarified. Based on these findings, universities should place greater emphasis on social contributions in research evaluation and the conferring process of academic titles. They should also construct a research evaluation system based on social influence (Geng and Ouyang, 2024), which guides researchers to obtain research resources through social contributions, thereby enhancing research output. (2) It provides a clear path for university researchers to enhance their research output. (3) It contributes modestly to the enrichment of related theories. This study reveals the potential mechanisms through which academic title structure affects research output, and it can help to address the shortcomings of the existing literature and enrich theories related to academic titles and research output.

Policy recommendations. Based on the above findings, this study recommends improving policies for introducing high-end talents; increasing support for scholars with associate senior titles; and establishing a research evaluation system based on social influence (Geng and Ouyang, 2024) to guide researchers in obtaining research resources and enhancing research output through social contributions.

- (1) Universities should improve policies for introducing high-end talents to optimize talent resources. Actively introduce

national-level talents and researchers with senior titles by providing support in terms of identity recognition, research funding, and team building through stratified classification (Hao and Zhang, 2021). Increase high-end talents proportion in university research teams to leverage their roles in contributing to society, obtaining resources, and enhancing research output.

- (2) Universities should increase support for researchers with associate senior titles. Given the insignificant negative effect of the proportion of associate senior titles on research output, it is recommended to take measures in two aspects. On one hand, encourage researchers with associate senior titles to actively participate in academic exchanges and research collaborations with top domestic and international universities to enhance their research capabilities. On the other hand, provide appropriate guidance for researchers with associate senior titles (Sun et al., 2009) to help them overcome research bottlenecks, alleviate the pressure of promotion assessments, and enhance research output (Jin et al., 2022).
- (3) Universities should construct a research evaluation system based on social influence (Geng and Ouyang, 2024) to guide researchers to focus on social contributions. This study finds that the indirect effects of social contribution and research resources on research output are not negligible. Especially for social contribution, it is not only more effective than research resources in enhancing research output, but also serves as a channel for obtaining research resources. Therefore, it is necessary to construct evaluation indicators that can promote social contributions (Xie and Wang, 2024), to guide university researchers to focus on the actual needs of economic and social development, solve real-world problems, and thereby obtain research resources and enhance research output.

Limitations and suggestions for future research. Certainly, there are some potential limitations that need to be further expanded in future. Though the sample of materials disciplines is highly representative, it is necessary to expand the research sample to other disciplines, entire universities, and even universities in different countries to explore the impact of academic title structure on research output. Furthermore, the issue of reverse causality, that higher academic titles have greater promotional effect on research output, and researchers with higher academic titles are attracted by universities with better research foundations, is also an important aspect that needs to be considered.

Data availability

The authors do not have permission to share the raw data.

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Note

- 1 The disciplines in Chinese universities are classified into three levels: discipline categories, first-level disciplines, and second-level disciplines. Taking the discipline of materials as an illustrative example, its category belongs to Engineering, Materials Science and Engineering is a first-level discipline under the category of Engineering, and within this first-level discipline, there are also second-level disciplines such as Materials Physics and Chemistry, and Materials Processing Engineering. If master and doctor degrees are granted based on the first-level discipline rather than the second-level discipline, it suggests that the research strength of the discipline is relatively strong.

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Author contributions

Mengmeng Zhang: Conceptualization, Methodology, Writing—Original draft. Liyuan Liu: Visualization, Software, Validation. Dongmei Zeng: Administration, Resources. Xiaoying Li: Reviewing, Resources. Correspondence to Dongmei Zeng or Xiaoying Li.

Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was not required as the study did not involve human participants.

Informed Consent

Ethical approval was not required as the study did not involve human participants.

Additional information

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