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Performance Aspiration in Meritocratic Systems: Evidence of How Academic Titles Affect the Performance of Universities

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Abstract: The study of academic title differences in universities helps to promote researchers' enthusiasm and is critical to the efficiency of university scientific research. This study examines the impact of academic title differences on the research efficiency of universities and explores its mechanism. Based on the perspective of production types, the scientific and technological innovation achievements of universities are divided into academic output and economic output. By using the stochastic frontier model, this paper evaluates the influence of different academic titles on the academic and economic production efficiency of scientific research innovation in universities. The research results show that academic output efficiency increases over time, while the economic output efficiency decreases over time. Researchers with associate professor titles are more efficient in academic research production, and researchers with lecturer titles are more efficient in economic research production. Regional economy is positively correlated with the economic output of universities and negatively correlated with academic output. The production and development of academic and economic research in different regions are not coordinated.

Keywords: tertiary education; academic title; academic title differences; efficiency of scientific research; stochastic frontier model

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1. Introduction

University researchers are crucial to scientific and technological innovation systems. The professional title system of scientific research personnel in universities is a fundamental framework for evaluating and managing professional abilities. It reflects the complexity of professional and technical work and displays the professional ability of scientific researchers to engage in this work. Titles represent the academic, teaching, and professional accomplishments of university researchers. They show that their abilities are valued and recognized by society, while significantly affecting their personal growth [1,2]. For university researchers, an excellent title system fosters a positive academic atmosphere, which is conducive to mobilizing enthusiasm and creativity and cultivating professional scientific research talents.

It is important to explore how different titles in university academia affect work efficiency. The main goal of academic title evaluation is to validate the professionalism of researchers [3]. To some extent, academic rank represents the scientific research ability of university researchers. The overall performance of academic research output, which can show how research resources are allocated and used, is known as research efficiency [4]. The title system has both incentive and constraint influences on scientific research activities. The well-known Peter Principle makes the point that, in a hierarchical structure, promotion may result in a decline in work performance and, along with the issue of distorted distribution,

will influence research performance [5,6]. For instance, when assistant professors are elevated to associate professors, research output typically declines [7]. Therefore, academic titles may affect the output of research and in turn affect the effectiveness of that research.

The past several decades have seen tremendous expansion of higher education around the world, accompanied by a growing quality of education and research; criteria for hiring researchers are also becoming stricter in different hierarchical universities [8]. Usually, the standard for measuring higher education personnel is their academic title. However, university researchers in higher education have a wide range of work tasks and roles in their daily work [9]. For example, some are more teaching-oriented, whereas others are more research-oriented. More teaching-oriented personnel are expected to offer research-based teaching compared with teaching expectations in the trade. Research-oriented individuals ensure the university has the legitimacy to offer accredited research-oriented teaching. Therefore, in best of both worlds, academics pursue both of these roles. In addition, clear roles will also engender strong performance outcomes [10].

The primary locations for researchers to assemble are higher education and research institutions worldwide. Those areas both obey the rules of the meritocratic system. The meritocracy usually decides the performance of faculty research. Academic meritocracy depends on publishing papers in peer-reviewed publications [11]. Considering the basic root of meritocracy, age, gender, ability, efficiency, artistry, technical knowledge, strength, and so forth can be considered to be elements of merit, depending on the circumstances [12]. In actuality, the test of merit should be individual talent. Scientific publication is usually considered a significant metric for academic performance [13]. University administrators and members of the scientific community generally continue to hold the belief that science is a young person's game and that only young scientists can be productive and produce high-quality research [14]. However, after graduating and entering the workforce as researchers, individuals usually take part in service to society or other kinds of external work, and their time focused on the research field facing the great pressure to publish papers in journals is extremely short. However, there are not as many prestigious journals as scholars, and it is increasingly difficult to publish.

Everyone should have an equality of opportunity to display his talent or lack thereof. However, different academic titles of researchers have different productivity. The higher academic titles could cause a distribution of resources and rewards imbalance (fellowships, jobs, grants, prizes, and medals) [13]. There are two possible reasons: institutional and individual characteristics. From an institutional perspective, there is the core of meritocracy on size and disciplinary growth. The research governance and management of American universities are more market-driven, while the higher education system in Europe is more state-driven [15]. Compared with the permanent appointment system, the renewal system for young faculty members has greatly improved their abilities of academic output in terms of institutional variables [16]. A study found that the European research elite is a highly homogeneous group of academics whose high research performance is driven by structurally similar factors, mostly individual rather than institutional [17]. Female researchers have a lower citation impact [18] and lower scientific productivity [19]. Female researchers occupy lower academic ranks [20], are less likely to secure funding [21], and have more restricted access to mentorship [22] and international collaboration [23] networks.

In recent decades, the decline in the number of tenured faculty positions combined with the increase in postgraduate enrollment has produced a highly competitive academic labor market [24]. Developed nations have a wealth of knowledge and experience in evaluating teachers' titles, and emerging nations face certain challenges in this regard [16]. With the economic and social development of developing countries, there is an increasing demand for research and innovation, and there are now clear requirements for these when evaluating professional titles. The evaluation of professional titles depends largely on the performance of teachers. The evaluation of teachers' performance is a more challenging issue because it involves multiple criteria as objectives [25]. Multi-criteria decision analysis involves a combination of multiple criteria in a weighted way and also produces visual

results, which is important for decisions [26]. Teachers are under greater pressure in teaching tasks, scientific research competitiveness, international training, and the promotion of professional titles, etc. [27]. In addition, the criteria for title promotion vary in their effectiveness as an incentive for young professors' research output in each area. Academic production has significantly changed before and after title review. This disparity is more pronounced for women than men, becomes worse as people grow older and less-educated, and it is more obvious in the field of social sciences than in the field of natural sciences [28]. In teacher evaluation, there are certain cultural variations in title differences [29]. In order to investigate the influencing factors of different titles in research universities on scientific research efficiency, this paper takes China as a research case.

According to the current literature, most studies on academic title differences and research efficiency focus on examining the incentive impact of title promotion on scientists' publications and the possible factors causing title differences from sociological and pedagogical perspectives. There are few studies on the mechanism of title differences, failing to provide reasonable economic explanations for the type of title differences. Thus, it is difficult to account for the impact of title differences on the research output of faculty members in research universities, let alone effectively reveal the mechanistic rationale mechanical principle that the professional title system stimulates in scientists' research efforts.

The main contributions of this paper are as follows. First, this paper examines the impact of academic title differences on the research efficiency of universities and explores its mechanism from the perspective of academic role theory and the meritocratic system. Taking Chinese research-oriented higher education schools as samples, this paper makes an empirical study on the above problems. Secondly, based on the perspective of product type, the scientific and technological innovation achievements of universities are divided into academic output and economic output. Using the stochastic frontier model, this paper evaluates the influence of different professional titles on the academic production efficiency and the economic production efficiency of scientific research and innovation in universities. The results can provide useful academic references for the reform of the title promotion system in universities, enrich the theory of science and technology evaluation, and improve the evaluation method of teacher team construction and research efficiency.

The remainder of this paper is arranged as follows. Section 2 is the research background and theoretical analysis. Section 3 introduces data, variables, and models. Section 4 presents the results. Section 5 presents the discussion and limitations. Section 6 draws a conclusion.

2. Background and Theoretical Analysis

Chinese higher education has entered a new period of development with the establishment of several world-class universities and majors. Some universities have made tentative changes to their title policies in order to improve their scientific research ability and attract outstanding talents. These changes have created a green channel for young doctoral students who have just graduated to become associate professors and professors. As managers of scientific research activities, universities should consider the formation of scientific research teams, and at the same time recognize the benefits of a fair title system for scientists and the relationship between scientists and the effectiveness of scientific research.

The academic title represents the academic level and teaching ability of teachers. A title is a qualification granted to university teachers who are engaged in teaching and scientific research after working for a certain number of years and obtaining scientific research results. According to the records, professors were first established as doctors in the Imperial College in the Han and Tang dynasties. In the Song dynasty, professors were established in state and provincial schools. In the Yuan, Ming, and Qing dynasties, professors were established in the Confucian schools in every state. Finally, there were teachers and deputy teachers in the newly established schools in the late Qing dynasty. Since then, the titles of university teachers have undergone a series of changes, from professor and assistant professor to full professor, professor and assistant professor, and then to professor, associate

professor, lecturer, and assistant professor. Moreover, since the founding of New China, university teachers in China have been divided into four levels: teacher, associate professor, lecturer, and assistant professor. An assistant professor's primary responsibility is to assist in teaching. A lecturer's primary responsibility is to provide one or more courses independently. An associate professor's primary responsibility is to thoroughly understand the discipline according to their curriculum, direct research projects, and turn the latest research results into teaching resources. A professor's primary responsibility is to supervise the development of the discipline studied and taught [1]. Faculty members with senior titles are more responsive to educational development, contribute more, and remain stable over time, while the opposite is true for faculty members with lower titles. A further study on research universities found that professors have made significant contributions to achieving world-class universities in "985" universities, while a young faculty's research and teaching potential has not been realized [30]. However, the lower the title is, the stronger the motivation of faculty members is in terms of title promotion, research awards, and honors [31].

The academic promotion system (known as the title system in China) provides university teachers with a clear goal and a strong motivation to achieve academic success in their long academic careers, and its importance cannot be understated. Since the 1990s, Chinese universities have used quantitative research evaluation to deal with the unpleasant phenomena of leadership will, seniority ranking, and human intervention in the evaluation of university titles. This evaluation method makes it possible to end the practice of ranking university qualifications and provide teachers with relatively fair and open evaluation rules. However, during the past 20 years, instrumental rationality, which focused on quantitative evaluation, has taken over the way universities assess scientific research. The alienation of professors' research motivations and the pursuit of output quantity and form have seriously affected the academic ecology of universities. The Chinese government has issued several consecutive guidelines to improve the university title evaluation system so as to curb this trend, including the Opinions on Deepening the Reform of the Title System issued by the General Offices of the CPC Central Committee and the State Council in 2017 and the Guidance on Deepening the Reform of the Title System of Teachers in Higher Education issued by the Ministry of Human Resources in 2018. These policies emphasize, to varying degrees, the importance of universities improving peer review, implementing representative work evaluation, and promoting classification evaluation, among other things, so as to foster a research environment dedicated to dedicated research and the pursuit of excellence and cleanliness.

The data shows that the largest numbers of university teachers' titles in the structure of China from 2009 to 2018 are lecturers, associate professors, professors, and assistant professors. Lv et al. (2009) investigated 29 universities and discovered four major patterns of the faculty title structure in research universities: a pyramidal structure with intermediate, associate senior, and positive senior in increasing order, an ovoid structure with the middle layer higher than the positive senior and intermediate at both ends, an inverted pyramidal structure with positive senior, associate senior, and intermediate in decreasing order, and a concave structure with positive senior, associate senior, and intermediate in it [32]. In comparison, top universities in the United States have an inverted pyramid-shaped faculty structure [33]. However, a study of Chinese universities in the "C9 Alliance" discovered that the structure of faculty titles is unreasonable, with a high proportion of teachers with senior titles, which affects the stability and continuity of the academic gradient [34]. In the long run, the faculty structure of some universities will become a "gray rhinoceros", resulting in varying degrees of structural imbalance [35].

People, including university professors, always react to incentives and constraints. According to Peter's theory, an organization's promotion system allows different levels of pay disparities to motivate employees. Competent individuals earn higher salaries when promoted to higher positions [36]. However, compared with teaching and service, research results are the most important determinants of teachers' salary increase, and there is a

significant correlation between salary level and researchers' publications [37]. However, due to the constraints of increasingly precise personnel systems in schools, university teachers have been transformed into academic workers. Under normal circumstances, scholars demonstrate their academic ability and gain the recognition of the academic community by publishing their works and participating in various academic activities. Universities decide to give scholars extrinsic compensation with the help of the academic community's evaluation of scholars. The evaluation of scholars by academic institutions is consistent with the academic community's evaluation of scholars. In practice, however, appraisal is an evaluation of people, and it is not easy to distinguish the influence of work climate and personnel skills. Under the pressure of survival, some scholars make efforts to cater to the assessment index and develop personnel skills. Through these efforts, they obtain positions in universities and use the university brand and the intangible assets of pre-emptive positions to produce more academic achievements in the unregulated academic environment in exchange for greater personal benefits. Spending time and effort on long-term research and basic research will seriously undermine development, which is the basis of external and internal development, under threat and temptation, especially for those who still have academic ideals and regard academics as noble undertakings.

The title evaluation of university teachers and scientific research efficiency influence each other, as shown in Figure 1. The scientific research efficiency of university teachers determines the title promotion. Title evaluation is the affirmation and recognition of teachers' scientific research achievements, while scientific research efficiency reflects the influence of scientific research achievements, which is the manifestation of scientific research evaluation. When the scientific research efficiency is high, and the scientific research results have important academic influence, it is easier for university teachers to obtain the promotion of professional titles, otherwise, they may not be promoted. There are both positive and negative mechanisms between them. Among them, the positive mechanism plays a positive role and can motivate researchers to create original academic results to a certain extent. They include the enthusiasm for research, research atmosphere, material incentives, performance evaluation, and promotion pressure.

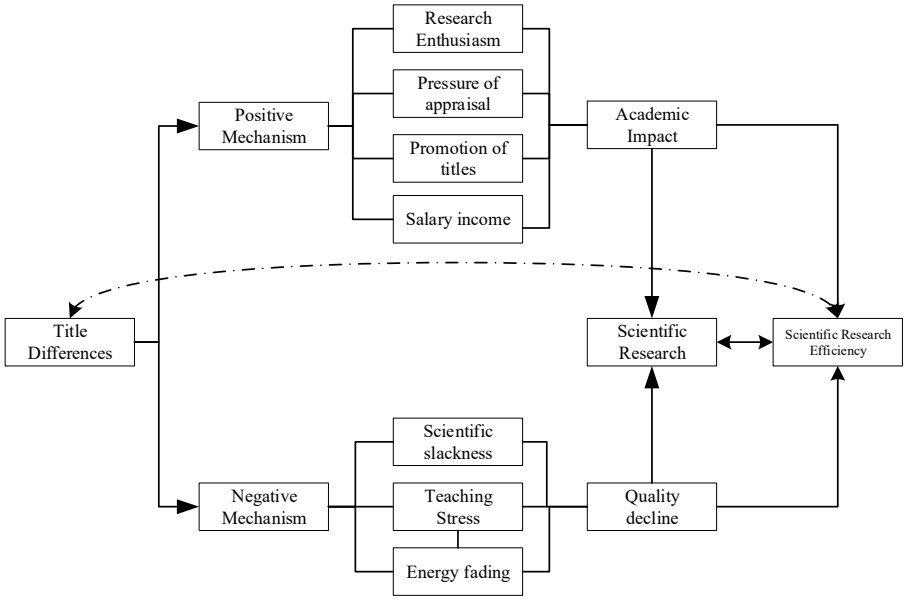

Figure 1. The influence mechanism of faculty title and research efficiency.

On the other hand, negative mechanisms have a suppressive effect on researchers' research efficiency, including promotion pressure, research assessment, slackness in research, and loss of creativity. The positive mechanism of research enthusiasm is the most important determinant for researchers engaged in research and is the only endogenous motivation for them to engage in research. It can stimulate teachers' enthusiasm for learning, and inspire

them to actively conduct practical learning activities and investigate cognition. Material rewards and performance appraisals recognize and affirm teachers' research achievements to a certain extent, which can stimulate teachers' research motivation and promote better development of their careers. Researchers with low titles will improve their research efficiency, so as to be promoted to higher titles and produce more research results. The pressure of promotion has two sides to a certain extent. Assuming that academic promotion is regarded as a positive mechanism, then in this case, it is an effective incentive which can strengthen the result-oriented consciousness of university teachers and motivate them to allocate their working time rationally to improve scientific research efficiency [38]. Assuming that it is regarded as a negative mechanism, then in this case, researchers are prone to do research for publication in order to cope with research assessment and title promotion. They only pursue the quantity of results but not the quality, which violates the original intention and basic guidelines of scientific research.

Positive and negative mechanisms are interchangeable in the same way as power and pressure. A certain level of negative effects benefits the research output. However, only a moderate negative effect can be converted into a positive effect. If the negative effect is too great, the positive effect will fade and cause researchers' research to become negative and slack, resulting in a decrease in research output. The primary causes of the negative mechanism are slackness in research, teaching pressure, and energy decline. There are two major reasons for this: on the one hand, researchers have limited energy not only to deal with heavy research and teaching workloads but also to deal with the pressure of family life. The income of university teachers varies according to the disciplines, and the income disparity is primarily related to seniority and academic output. Research output and management involvement have a greater impact on income than teaching, and dissertations have a greater impact on income levels than writing.

Furthermore, with an increase in age, a person's income is also increasing, and it is difficult to concentrate on research under multiple pressures. Some researchers gradually become unsuitable for research work and, as a result, become slack in their scientific research. Furthermore, many universities have clearly stated this point. Many universities now clearly state that teachers cannot be promoted without completing the assessment of teaching and research workload, which puts pressure on teachers.

3. Method

3.1. Variables

This paper mainly researches the influence of university title structure on the research efficiency of universities. The scientific research activities of universities cannot be separated from the input of various production factors. Manpower and capital input are the most commonly used indicators to measure scientific research investment in universities. This paper uses full-time R&D personnel to measure the indicators of research manpower input. The indicator of capital investment uses R&D expenditure. Since it is a flow indicator, it reflects the actual R&D capital investment during the year. However, actual R&D activities affect the knowledge production in the current period and the future knowledge production. According to the current R&D expenditure calculation method, there is a deviation in measuring R&D capital investment. In this paper, the perpetual inventory method is used to calculate R&D capital investment, and its calculation formula is as follows.

$$K_{it} = (1 - \delta)K_{it-1} + E_{it} \tag{1}$$

$$K_{i0} = \frac{E_{i0}}{(g + \delta)} \tag{2}$$

where K_{it} is the R&D capital stock in period t of region i, K_{it-1} is the R&D capital stock in period t−1 of region i, δ is the depreciation rate, and the depreciation rate is taken as 15%, drawing on the existing literature [39,40]; E_{it} is the real science and technology expenditure in period t of region i, and is deflated by the price index of internal expenditure on science and technology in universities based on the literature using 2009 as the base

period, the value index of R&D expenditure in higher education = 0.55 * Consumer Price Index + 0.45 * Fixed asset investment price index. g is the average growth rate of the real internal expenditure on science and technology of all universities in the region in the sample interval [41,42].

Under the existing university system, the scientific research outputs of universities mainly include academic papers, publications, patents, and other achievements. Drawing on existing studies [43,44], this paper divides the research outputs of universities into academic output and economic output. The number of published academic papers and scientific and technological monographs is taken as the academic output of scientific research [45]. The weight of scientific and technological works and papers in academic output and the value of technology transfer contracts and patent sale contracts in economic output are determined by reference [44].

Based on the main composition of university titles, the title structure in this paper refers to the proportion of professors, associate professors, lecturers, and assistant professors with university faculty titles in the total number of R&D personnel. Among them, the measure of professor (PROF) is measured by the ratio of faculty with professor titles to the total number of R&D research method personnel, which is the same as other associate professors, lecturers, and assistant professors. Due to the different external environment, such as the economic development level, historical conditions and situation in different regions, their efficiency performance may also be different, so as to study the influence of different professional titles on university scientific research efficiency more accurately. In this paper, the variables of regional characteristics are controlled. Existing studies suggest that per capita gross domestic product (PGDP) and per capita foreign direct investment (PFDI) are controlled in various regions. Time (T) is also provided to illustrate the potential temporal variability of research efficiency. The symbols and definitions of each variable are described in Table 1.

3.2. Data

The data on research inputs, outputs and characteristics of universities in this paper are dated from 2009–2018 and obtained from the Compilation of Science and Technology Statistics of Higher Education Institutions (2010–2019). Based on the coordinated deployment of the Ministry of Education and the unique circumstances of scientific and technological work in higher education institutions, the Compendium of Science and Technology Statistics of Higher Education Institutions was developed. According to the National Annual Report on Science and Technology of Universities, the data collection was thoroughly processed and organized to reflect the overall state of science and technology operations in higher education institutions. The materials in this compilation were gathered and organized by using the international system of classification for scientific study. It is a comprehensive and informative data collection that makes it easier to compare the science and technology activities of the domestic and international sectors in higher education institutions. Information on regional characteristics, investment price index of fixed assets and consumer price index came from the EPS database (https://www.epsnet.com.cn/index.html#/Index, accessed on 15 August 2020).

3.3. Model

SFA can not only measure the efficiency of each individual, but also investigate the specific effects of various factors on individual efficiency differences. The basic form of the stochastic frontier efficiency measurement model citing efficiency influencing factors proposed by Aigner et al. (1977) [46] and Meeusen and Van DenBroeck (1977) [47] is as follows.

$$Y_{it} = f(x_{it}, t)exp(v_{it} - u_{it})(i = 1, 2, \cdots, N; t = 1, 2, \cdots, T) \quad (3)$$

where, Y_{it} denotes the real academic output versus the real economic output in the research efficiency of the i province in period t; x_{it} is the input variable; $f(x_{it}, t)$ is the transcendental log production function; $v_{it} - u_{it}$ is the regression error term of the composite structure. v_{it}

is a random error term reflecting the statistical noise and the technical inefficiency term u_{it} are independent of each other and obey $N(0, {\sigma_v}^2)$.

Table 1. Definition of variables.

Variables	Symbols	Definition or Calculation
Research output variables		
Academic Outputs	Y1	Scientific and technical publications (part) (weight 0.3)
		Academic papers (piece) (weight 0.7)
Economic outputs	Y2	Technology transfer contract amount (thousand dollars) (weight 0.5)
		Contract amount of patent sale (thousand dollars) (weight 0.5)
Research input variables		
Researcher inputs	L	Full-time personnel for R&D activities (persons/year)
Research Capital Investment	K	R&D funding capital stock (thousand dollars)
Efficiency Influencing Factors		
Percentage of scientific personnel with the title of professor	PROF	Proportion of scientific researchers with professorial titles in provincial/municipal areas
Researchers with the title of associate professor	ASSO	Proportion of scientific researchers with the title of associate professor in the province/city area
Researchers with the title of lecturer	LECT	Proportion of scientific researchers with the title of lecturer in provinces/cities
Researchers with the title of assistant professor	ASSI	Proportion of scientific researchers with the title of assistant professor in provinces/cities
Control Variables		
GDP per capita	PGDP	Logarithm of the ratio of provincial/municipal GDP to regional population
FDI per capita	PFDI	Logarithm of the ratio of FDI to total regional population in provinces/municipalities
Time Factor	T	2009 as base period, in increasing order

The technical efficiency of scientific research activities is defined as the ratio of the observed real output expectation to the expectation when the efficiency loss is zero in the ideal state, where the calculation formula is as follows.

$$TE_{it} = \frac{E[f(x_{it}, t)\exp(v_{it} - u_{it})]}{E[f(x_{it}, t)\exp(v_{it} - u_{it})|u_{it} = 0]} \tag{4}$$

In this paper, the usability of the model is explored using the model of inefficiency impact factors proposed by Battese and Coelli (1992) [48] applicable to panel data.

$$u_{it} = u_i \exp[-\eta(t - T)](i = 1, 2, \cdots, N; t = 1, 2, \cdots, T) \tag{5}$$

$$\gamma = \frac{\delta_u^2}{\delta_v^2 + \delta_u^2} \tag{6}$$

u_i is a non-negative random variable whose distribution obeys $N^+(u, {\sigma_u}^2)$, η is the time-varying reference to be estimated, $\eta = 0$ denotes the technical inefficiency without time variation, $\eta > 0$ and $\eta < 0$ denotes the inefficiency term u_{it} decreasing and increasing with time, respectively, γ denotes the weight of technical inefficiency in the random disturbance term, and takes values in the range of [0,1]. $\gamma = 0$ indicates that there is no technical

inefficiency term, at which point the SFA model is no longer applicable. γ value close to 1 indicates that the deviation of the actual output from the frontier in science and technology activities mainly originates from the technically inefficient term, and the SFA model is better set up at this time.

This paper focuses on the effect of teachers' title structure on university research efficiency in different provinces, which requires the control of variables characterizing the external heterogeneity of different provinces. This paper explores technical efficiency and its impact by using a stochastic frontier model proposed by Battese and Coeli (1995) [49] with the introduction of efficiency influencing factors, which takes the following form.

$$u_{it} = \delta_0 + \delta_i Z_{it} + w_{it} \tag{7}$$

where δ_0 is the constant term, Z_{it} is the non-efficiency influencing factor, δ_i is the coefficient of the influencing factor, and w_{it} is a random variable assumed to obey independent identical distribution. Regarding the form of the production function, the transcendental logarithmic production function is chosen in this paper. Since it is uncertain whether the output elasticity is fixed over time and whether the technology is neutralized in the research analysis, the assumptions of fixed output elasticity and technology neutrality are relaxed in the transcendental logit production function, in order to better avoid the estimation deviation caused by the wrong function form. Therefore, the stochastic frontier model beyond the log production function is chosen in this paper, which takes the following form.

$$f(x_{it}, t) = \beta_0 + \beta_1 lnL_{it} + \beta_2 lnK_{it} + \frac{1}{2\beta_3 (lnL_{it})^2} + \frac{1}{2\beta_4 (lnK_{it})^2} + \beta_5 (lnL_{it} lnK_{it}) \tag{8}$$

where L_{it} is the full-time personnel of R&D activities and K_{it} is the capital stock of R&D investment.

In the stochastic frontier model, unavoidable efficiency losses are inscribed through technical efficiency losses u. The technical efficiency loss equation for the efficiency of university research, which incorporates different title structures, is as follows.

$$u_{it} = \delta_0 + \delta_1 PROF_{it} + \delta_2 ASSO_{it} + \delta_3 LECT_{it} + \delta_4 ASSI_{it} + \delta_5 PGDP_{it} + \delta_6 PFDI_{it} + \delta_1 T + \omega_{it} \tag{9}$$

4. Empirical Analysis

4.1. Regional Research Efficiency Measurements

According to the calculated efficiency values of academic output and economic output in each region over the years, the median value, a standard, represents the output efficiency per year and region. The median is used because it is not affected by the extreme values of the distribution sequence, which improves the representativeness of the value. Regions above the median value are labeled as "H", while those below the median value are labeled as "L". Academic output is ahead of the economic output in the table. Different combinations of H and L represent each region's status.

The efficiency of academic output and economic output are different in different regions and different periods. Here, the efficiency status in 2018 is used for further illustration, and the results are shown in Figure 2, with the horizontal axis indicating economic output and the vertical axis indicating academic output. In 2018, the regions with a low academic output and economic output included Tianjin, Anhui, Jilin, Shanxi, Hainan, Qinghai, Heilongjiang, Guangxi, and Ningxia; the regions with a high academic output and a low economic output included Hubei, Hebei, Guizhou, and Xinjiang; the regions with a high academic output and a low economic output included Hubei, Hebei, Guizhou, Xinjiang, Xinjiang, Yunnan, and Tibet; the regions with a low academic output and a high economic output included Shanghai, Chongqing, Zhejiang, Fujian, Jiangxi, and Liaoning; the regions with a high academic output and a high economic output included Beijing, Guangdong, Jiangsu, Hunan, Shandong, Henan, Sichuan, Shaanxi, Gansu, and Inner Mongolia. Since it

is difficult to define absolute judgment criteria for academic output and economic output, their judgment is relative.

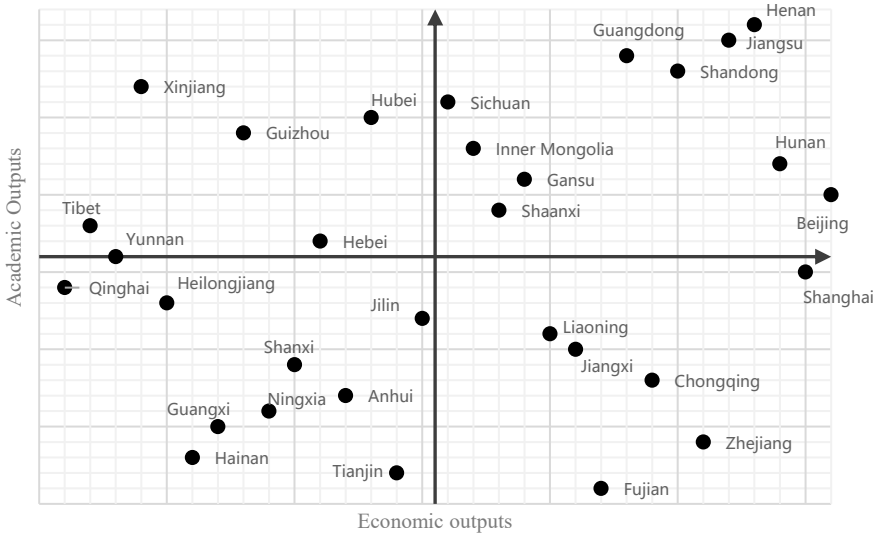

Figure 2. Economic output and academic output efficiency matrix in 2018.

Based on Table 2, five patterns of research output in each region are further compiled, and the results are shown in Table 3.

Table 2. Research efficiency status by region, 2010–2019.

Region	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Anhui	HH	HH	HH	HH	HH	HH	LH	LH	LL	LL
Beijing	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH
Fujian	LH	LH	LH	LH	LH	LH	LH	LH	LH	LH
Gansu	LL	HL	HL	HL	HL	HL	HL	HL	HL	HH
Guangdong	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH
Guangxi	HH	HH	HH	LH	LH	HL	HL	LL	LL	LL
Guizhou	HH	HL	HH	HH	HH	HL	HH	HL	HL	HL
Hainan	HH	HH	HH	HH	HL	HL	HL	LL	LL	LL
Hebei	HH	HH	HH	HH	HH	HH	HH	HH	HH	HL
Henan	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH
Heilongjiang	HL	HL	HL	LL	LL	LL	LL	LL	LL	LL
Hubei	HH	HH	HL	HH	HL	HL	HH	HL	HL	HL
Huanan	HH	HH	HH	HH	HH	HH	HL	HH	HL	HH
Jilin	LL	LL	LL	LH	LH	LH	LL	HL	LH	LH
Jiangsu	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH
Jiangxi	HH	HH	HH	HH	HH	HH	LH	LH	LL	LH
Liaoning	HH	LH	HH	HH	LH	LH	LH	LH	LH	LH
Inner Mongolia	HH	HH	HL	HL	HL	HL	HL	HL	HL	HH
Ningxia	HH	HH	HL	HH	HL	HL	HL	LL	HL	LL
Qinghai	HL	HL	HL	HL	HL	HL	HL	HL	HL	LL

Table 2. *Cont.*

Region	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Shandong	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH
Shanxi	LH	LH	LH	LL	LL	LL	LH	LH	LH	LL
Shaanxi	HH	HH	HH	LL	LH	LH	LH	LH	LH	HH
Shanghai	LH	HH	HH	HH	HH	LH	LH	LH	HH	HH
Sichuan	HL	HH	HH	HH	HH	HH	HH	HH	HH	HH
Tianjin	LH	LH	LH	LH	LH	LH	LH	LH	LH	LH
Tibet	LH	LH	LH	LL	LL	LL	HL	HL	HL	HL
Xinjiang	HH	HH	HH	HH	HH	HH	HL	HH	HL	HL
Yunnan	LH	HH	HH	LH	HL	HH	HL	HL	LL	HL
Zhejiang	HH	HH	HH	LH	LH	LH	LH	LH	LH	LH
Chongqing	HH	HH	HH	HH	HH	HH	LH	HH	LH	LH

Table 3. Analysis of the status of regional scientific research types.

Upgrade Type	Stage Region	Stage Region
Mature stage	HH (6)	Beijing, Hebei, Guangdong, Jiangsu, Shandong, Henan
Catch-up period	LH(HL)→HH (5)	Shanghai, Sichuan, Shaanxi, Hunan, Gansu
Fluctuation period	HH→HL(LH) (10)	Chongqing, Zhejiang, Hubei, Jiangxi, Jilin, Yunnan, Guizhou, Liaoning, Xinjiang, Tibet
Stable period	LH (2)	Fujian, Tianjin
Decline	HH→HL(LH)→LL (8)	Anhui, Guangxi, Hainan, Heilongjiang, Ningxia, Shanxi, Qinghai, Inner Mongolia

Note: The numbers in ( ) are the total number of areas of the type.

The first type is the mature period, i.e., the period in which the research output pattern is maintained at a high level and both academic and economic outputs develop in a coordinated manner. There are mainly five regions: Beijing, Hebei, Guangdong, Jiangsu, Shandong, and Henan.

The second type is the catch-up period, i.e., the period in which the evolution from low academic and high economic outputs or high academic and low economic outputs to high academic and high economic outputs occurs. This type includes Shanghai, Sichuan, Shaanxi, Hunan, and Gansu.

The third type is the fluctuation period, that is, the period in which the evolution from high academic and high economic outputs to low academic and high economic outputs or high academic and low economic outputs occurs. This type includes Chongqing, Zhejiang, Hubei, Jiangxi, Jilin, Yunnan, Guizhou, Liaoning, Xinjiang, and Tibet.

The fourth type is the stable period, in which the output efficiency of regional research has been stable at a low academic and high economic level during the period 2009–2018. This type includes Fujian and Tianjin.

The fifth type is the decline period, gradually changing from high academic and economic output efficiency to low academic and low economic efficiency. These regional universities deserve the attention of relevant government departments. And universities should also look for problems within themselves.

4.2. Testing the Applicability of the Model

The applicability of the stochastic frontier model is tested and the functional form of the model is determined. First, the inefficiency term and its time-varying characteristics are

examined by the transcendental log production function in the stochastic frontier analysis without considering the influence factors. The results are shown in Table 4. In the estimated models of academic output and economic output, both pass the 1% significance level test, indicating that there is an inefficiency term and the efficiency varies with time, and the model is a time-varying model; secondly, in the estimated model of academic output, the inefficiency term of academic output decreases with time, i.e., there is a trend of increasing efficiency with time; however, in the estimated model of economic output, the inefficiency term of economic output decreases with time, indicating that there is a trend of increasing efficiency with time. Finally, the generalized likelihood ratio (LR) in the model is much larger than the critical value and close to 1, and the research inefficiency of both academic and economic outputs exists, which confirms that the stochastic frontier model setting is applicable to this study.

Table 4. Stochastic frontier estimation model of scientific research efficiency without considering efficiency influences.

	Academic Outputs		**Economic Outputs**	
Constant	9.021 ***	(4.704)	−12.587 ***	(−2.290)
LnK	−0.972	(−1.512)	0.274	(0.086)
LnL	−1.151 ***	(−2.392)	3.718 **	(1.973)
(LnK)2	0.029	(0.213)	0.013	(0.019)
(LnL)2	0.051	(0.717)	−0.204	(−0.524)
LnKLnL	0.159	(0.744)	0.014	(0.014)
σ^2	0.646 ***	(2.293)	4.711 **	(2.217)
γ	0.989 ***	(188.408)	0.947 ***	(35.994)
μ	−1.598 *	(−1.782)	−4.225 ***	(−3.231)
η	0.036 ***	(5.159)	−0.048 ***	(−2.324)
OLS-log	185.641		−291.210	
log	255.425		−260.734	
LR	139.566		60.952	
Threshold values	4.170		4.170	

Notes: *, ** and ***, respectively, indicate significance at the levels of 10, 5%, and 1%; words in brackets mean the value in the number is a standard error, as shown in the table below. Hereinafter the same.

In order to verify whether the title structure has a substantial effect on the research efficiency of universities, this paper constructs a generalized likelihood ratio test beyond the logarithmic production function model. The results show that the generalized likelihood ratios of research output all pass the 1% significance level test, which indicates that the factors selected in this paper do have a substantial influence on the research efficiency of universities, and can effectively explain the differences in the efficiency of research output among universities in different regions. Table 4 shows the stochastic frontier model without considering the effect of efficiency. In the estimated equation of academic output, the research staff input is negatively and significantly correlated with the academic output, while the research capital input is also negatively correlated but does not pass the statistical test. In the economic output estimation equation, research staff input is positively and significantly correlated with economic output, while research capital input is also positively correlated but does not pass the statistical test. This shows that in academic output, the inputs of research personnel and capital are redundant and inefficiently utilized, while in economic output, the inputs of research personnel have a significant impact on economic output and have a positive effect on improving efficiency.

4.3. Analysis of the Effect of Title Structure on the Efficiency of University Research

From the estimation results of the inefficiency function of academic output, the estimated coefficients of professors, associate professors, and lecturers in the title structure significantly pass the test at the 1% level, while the estimated coefficients of assistant professors fail to pass the test, i.e., the impact of assistant professors on the efficiency of research academic output is not statistically significant, as shown in Table 5. The impact of each factor on the loss of research efficiency, if the estimated coefficient of a factor is negative, indicates that the impact on research efficiency has a positive effect and, conversely, a negative effect. The estimated coefficients of professors and lecturers are significantly positive, while the estimated coefficients of associate professors are significantly negative, indicating that the group of professors and lecturers are less efficient in enhancing academic output in scientific research than researchers with the title of associate professor, which shows that researchers with the title of associate professor have a higher output and efficiency in academic research output and are the offensive force in academic contribution to research.

Table 5. Stochastic frontier estimation model of scientific research efficiency considering efficiency influencing factors.

	Academic Outputs		**Economic Outputs**	
Variables	**Coefficient**	**T-Value**	**Coefficient**	**T-Value**
Constant	0.383	(0.660)	−25.585 ***	(10.508)
LnK	3.338 ***	(5.795)	−0.963	(−0.474)
LnL	−1.297 ***	(−3.397)	8.089 ***	(5.860)
(LnK)2	0.192	(1.219)	−0.026	(−0.035)
(LnL)2	0.308 ***	(3.356)	−0.554 **	(−1.629)
LnKLnL	−0.658 ***	(−2.674)	0.195	(0.198)
Constant_1	−2.950 ***	(−2.548)	16.089 *	(2.043)
PROF	6.131 ***	(2.320)	−8.476	(−1.193)
ASSO	−12.940 ***	(−2.784)	27.836 ***	(2.897)
LECT	5.259 ***	(2.259)	−22.173 ***	(-3.202)
ASSI	−1.402	(−1.203)	18.891 ***	(2.974)
PGDP	0.511 *	(2.111)	−5.670 ***	(−2.345)
PFDI	0.122	(1.083)	0.943	(1.488)
T	0.001	(0.059)	0.454 ***	(3.014)
σ^2	0.120 ***	(4.143)	1.359 ***	(2.800)
γ	0.939 ***	(63.485)	0.882 ***	(17.131)
OLS-log	185.641		−291.210	
Log	218.979		−261.397	
LR	66.676		59.624	

From the estimation results of the inefficiency function of economic output, the estimated coefficients of associate professors, lecturers, and assistant professors in the title structure significantly pass the test at the 1% level, while the estimated coefficients of professors fail to pass the test, i.e., the effect of professors on the efficiency of academic research output is not statistically significant. The estimated coefficients of associate professors and assistant professors are significantly positive, while the estimated coefficients of lecturers are significantly negative, indicating that the two groups of associate professors and assistant professors do not contribute as much as the lecturers' efficiency in improving the scientific efficiency of academic output. Thus, researchers with the title of lecturer in

economic research output have a higher output and efficiency, and are an important force in the economic output of research.

In the academic output and economic output models, there is a difference in the output efficiency of GDP per capita on the type of university research. In the academic output, the estimated coefficient of GDP per capita is significantly positive and shows a negative effect; however, in the economic output model, the estimated coefficient of GDP per capita is significantly negative and shows a positive effect. This may be due to the higher possibility of redundant investment in basic research science and technology funding for universities in regions with better economic development and the lower utilization rate of funds, resulting in a negative relationship between regional GDP per capita and the efficiency of academic output of universities. As for the economic output, the regional GDP per capita shows a positive correlation with the efficiency of economic output of universities, which indicates that the regional economic funding in the research activities of universities has been fully utilized to enhance the research efficiency. The estimated coefficient of per capita FDI is positive, but it does not pass the significance test, which indicates that there is no moderating effect of per capita FDI between the difference of titles and the research efficiency of universities.

5. Discussion

Clear roles will also engender strong performance outcomes [10]. The "academic systems" are overly "meritocratic" [8]. The meritocratic theoretical idea means performance is assumed to follow formalized achievement rather than subjective norms. Therefore, to perform better in scientific research, it is essential to have a defined role positioning that is driven by personal interests.

Based on the analysis of the mechanism of the impact of title difference on scientific research efficiency and empirical results, we can see that Chinese universities' academic output and economic output are not coordinated, with large differences and serious polarization. Most regions in the mature stage are located in the regions with better economic development, enabling the academic output and economic output to be better coordinated. Provinces in the catching-up period make adjustments after universities realize their problematic shortcomings and move closer to the mature period after continuously improving their research output. As for provinces in the fluctuating period, they fluctuate back and forth because they have not found the balance point of scientific research development in academics and the economy. Possible reasons are that the increase in investment in scientific research and innovation in universities brings the development of basic research, which increases the output of papers and publications but fails to transform the foundation into actual economic capacity. Once the investment in economic transformation is too much, it is found that the basic research is not motivated enough to achieve balanced development. For the output of regional universities in the declining period, there may be defects, such as the imperfect transformation mechanism of achievements and lack of promotion and application platforms, which cause academic research and economic output to show signs of decline.

Associate professors have a higher research efficiency in terms of academic output. Regarding economic output, associate professors and assistant professors contribute less to improving academic output and research efficiency than lecturers. This study is distinct from previous research [7]. One possible explanation is that there is a dual assessment of academic and economic output under the Chinese teacher title system. The academic research efficiency of associate professors is proportional to their age. When given enough time and energy, the group of associate professors already has a deeper understanding of the research field and is more capable of high efficiency. Associate professors who are promoted to full professors are more likely to obtain administrative positions and specific academic resources. Regarding economic output, promotion causes distributional distortions that impact performance [6]. Compared with teaching and service, research is the most important determinant of teachers' salary growth. There is a significant correlation

between salary levels and the publication of research results, which is related to the high economic output of lecturers [37].

In the model of academic output and economic output, there are differences in the output efficiency of GDP per capita on the types of scientific research in universities. In the academic output, the estimated coefficient of GDP per capita is significantly positive and shows a negative effect; however, in the economic output model, the estimated coefficient of GDP per capita is significantly negative and shows a positive effect. It may be because the higher the degree of economic development in the regions with better economic development, the higher the possibility of redundancy of investment in basic research science and technology funding for universities, and the lower the utilization rate of funds, resulting in a negative relationship between regional GDP per capita and the efficiency of academic output of universities. As for economic output, the regional GDP per capita shows a positive correlation with the efficiency of the economic output of colleges and universities, which indicates that the funding of the regional economy has been fully utilized in the research activities of colleges and universities and improves the efficiency of research.

6. Limitation

The research in this paper also has certain limitations. First, due to the limited sample size, this paper does not consider a longer lag period. For example, it fails to consider the long-term effect of the difference in title structure on the research efficiency of universities. Secondly, the worldwide disaster caused by COVID-19 and its variants has changed the behavior and psychology of researchers [50], so the scientific research efficiency of scientific and technological work with different professional titles during the pandemic situation is worth studying. Thirdly, since there are many factors affecting the research efficiency of universities, not only limited to the teachers' titles, the heterogeneous characteristic variables of regions are also much greater than the regional characteristic factors included in this paper. For this reason, subsequent studies should extend the sample and lag periods when data are available and explore more complete factors influencing university research efficiency.

7. Conclusions

From theoretical implications, this paper examines the impact of academic title differences on the research efficiency of universities and explores its mechanism from the perspective of academic role theory and the meritocratic system. From practical implications, we discovered that the efficiency of academic output tends to increase over time, whereas the efficiency of economic output tends to decrease over time. Associate professors are efficient in terms of academic output. In the aspect of academic research output, researchers with associate professor titles have higher output and efficiency, and they are the offensive force of academic research contribution. Researchers with lecturer titles are efficient in terms of economic output. Lecturers contribute more to improving the research efficiency of academic output than associate professors and assistant professors. Researchers with lecturer titles in economic research output have higher output and efficiency, and they are the significant force of the economic research output.

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