Research Resources and Scientific Outputs in China: Based on a Survey Data

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Abstract--**Based on a nationwide survey data on Chinese research personnel, this paper analyzes the status of research resource acquisition and the influential factors of the number of papers published. The statistic results show that the research personnel, with doctoral degree and senior professional title, have obvious advantages to acquire research resources. Moreover, possession of more resources significantly increases the total number of published papers, while age, gender, and administrative post are not statistically significant in the regression model.**

I. RESEARCH QUESTION

The issue of scientific research resources acquisition or distribution is a main concern for scientific community. First, in big science times, organized research program/projects gradually occupy the dominant position. There must be organizations providing funds for scientific research, because the cost of natural science experiment is huge which means it is unable to be undertaken personally. Therefore, scientific research resources is important for research personnel [1]. Secondly, research resources can also be regarded as generalized incentives or the transformation form of rewards, so rewards can be easily transformed into scientific research resources which making the stratification of the scientific community into structuralization [14]. Moreover, people pay more attention on the rational allocation and the effective use of public resource because of a large number of research inputs of governments. The public worries about that the unequal allocation of research resources will be the main source of scientific community's inequality, or is to strengthen the key factors for the Matthew effect, which means the phenomenon where "the rich get richer and the poor get poorer"[9].

The number and influence of research outputs are the key indicators which measuring the recognition of a person's academic authority in the scientific community. The priority of scientific discovery is very important for scientists [4], and the way to publish papers and patent applications is a good proof for the priority of scientific discovery [13]. For the scientific system, the important function of published papers is embodied in exchange of research outputs, enriching knowledge system and promoting development of science. In reality, a high level of papers published can enable the authors to obtain a good reputation and the peer's recognition of their research capabilities, which is conducive to the authors obtaining research funds and job promotion [7]. As a result, most research personnel attach great importance to the outputs and strive for the peer recognition [5]. However, there are researchers argue that stratification in scientific field is not fixed by research performance. Based on a sample survey of 576 scientists, Hargens and Hagstrom found that when research outputs was controlled, the current reputation of scientists were highly relative to the reputation of universities which they graduated from [7].Many researchers focus on studies of factors which affecting academic status of scientists. Merton anylized status difference of scientists and publication rates based on scientists from 17 physics departments which including top ones as well as normal ones. He found that compared with physicists from the normal universities, people from the top universities had better performance on publication rates. 91% paper from top universities' physicits were publicated while the rate was 72% in normal universities [8].Xie and Shauman found gender differences for scientists gradually diminished. The so called gender differences rooted in gender inequality in research resources acquisition [12]. Chinese researchers also use empirical method to analyze the issues. Gu found that academic identity had significant positive effect on research resources acquisition and administrative status had significant positive effect on publication [6]. Qin and Weistudied the principle of universalism in China's scientific community. They discussed qualification, power and social network were more major influence variables [11].

The issue of this paper focuses on the academic status and the impact factors of scientific research personnel in the field of scientific research resources and output. The output of scientific research personnel includes many kinds of forms [10], and the selected papers published is chosen as the representative output in this paper. In this paper, we mainly study two questions: first, which factors affect the scientific research personnel to obtain research resources; second, which factors influence the number of published scientific research papers. The relationship between the scientific research resource and the published scientific research paper will be discussed.

Cole brothers [2] took the United States in the field of physics as an example. Their study has proved that the serious stratified phenomenon exists in the scientific community, but this kind of hierarchical mainly followed the principle of universalism [3]. Institution, system and development stage lead to the difference of social stratification mechanism, and there must be some aspects of the science and technology stratification in Chinese social environment.

The purpose of this study is to investigate the scientific research personnel operation and applicability of universalism norm in China by the stratification study.

II. RESEARCH HYPOTHESIS

Based on the norm of universalism, we can suppose that the research resources acquisition has a correlativity

relationship with scientific outputs. Also, we can suppose that the academic ability of research personnel may impact on acquiring research resources and scientific outputs. If a researcher could acquire more research resources, he might have more scientific outputs, and vice versa. Age, gender, administrative position et al. could not reflect the academic ability of research personnel, so those factors may not impact on acquiring research resources or scientific outputs.

III. DATA, MEASURES AND METHODS

A. Data selected

The analyze data were collected from the nationwide sample survey of "Status of Chinese research personnel undertaking research projects". This survey was funded by China Association for Science and Technology and conducted by Renmin University of China in 2010. The target population is Chinese research personnel. Using systematic sampling method, the samples were randomly picked up from 22 research institutes, 26 universities and 34 enterprises of 21 provinces. The questionnaire was self-administered and 5554 valid questionnaires were obtained. The survey collected the information of respondents' applications and participation of research projects as well as research outputs during 2007-2009.

It should be noted that in this paper we only select respondents from two kinds of danwei (danwei is a Chinese word which means the institution which person is employed): research institutes and universities. We also remove the individuals who starting work after 2008 from our samples. Meantime, due to missing values of some variables, there are 3428 observations in the regression model.

B. Dependent variables

Measuring of research resources (RES) is constructed by three original variables [6]: the number of projects hosted, the number of national projects hosted and the total fund of research projects in 2007-2009. We combine the variables to come up with three RES types:

(1) IF the total fund of research projects is greater than or equal to 500,000 RMB or the number of projects hosted is greater than or equal to 3 and the number of national projects hosted is greater than or equal to 1, then RES=1 and will be defined as the "abundant type".
(2) If the number of projects hosted is equal to 0, then RES=3, which means the "lack type".
(3) Otherwise, RES=2, which is defined as the "medium type".

Measure of the research output is the number of papers. The survey asked individuals about the number of papers cited by SCI, EI or Chinese Core Journals in 2007-2009. Specially, in order to avoid extremum, if the number of papers is greater than 21, it will be recoded to 21.

C. Independent variables

The independent variables are divided into individual factors including age, gender, education, professional title, administrative position, and non-individual factors including the type of his/her danwei, whether has a Ph.D. program and the area of his/her danwei.

The education is divided into doctor, master and B.A. or under. The professional title is divided into senior, sub-senior, junior and entry-level. The administrative position is divided into the manager and general staff according to whether the individuals occupy a middle-level management position in danwei or not. The type of danwei includes university and research institute. The area of danwei can be divided into east, center and west China by geographical region. Whether has a Ph.D. program can indicate the academic distinction of a danwei. Detailed variable classification and sample distribution are shown in table 1.

D. Statistical method

There are many factors which affected the scientific research personnel to acquire research resources and gaining scientific outputs. Firstly, we used contingency table and mean classification to compare group differences by a single variable in descriptive statistics. Then, in order to test the independent effects of the independent variables under the condition of statistical control, we used the multiple regression analysis method. A multi-nominal logistic regression model, which has three categorical variables, was built to predict RES; meanwhile, a multiple linear regression model was built to predict the number of published papers.

IV. DESCRIPTIVE STATISTICS

We present basic descriptive statistics of the variables in Table 1. Overall, in terms of research resources acquisition, the proportion of "abundant type", "medium type", "lack type" are 29%, 40%, and 32% respectively. Meanwhile, for the outputs of research personnel in 2007-2009, the average number of published papers is 4.4.

A. Individual factors

Men have a certain advantage over women. In terms of scientific research resources, the proportion of male research personnel belonging to the resource abundant type is 33%, while the female research personnel is 19%. In terms of outputs, during those three years, the average number of published papers of male research personnel is 4.8, while that of female research personnel is 3.5.

Research personnel who have a doctor degree have obvious advantages. In respect of research resources acquisition, 48% Ph.D. research personnel belong to the resource abundant type, only 10% Ph.D. research personnel belong to the resources lack type, which was better than the other research personnel; in the aspects of outputs, the Ph.D. research personnel has 7.6 papers in

average, that is about three or more times than the other research personnel during those three years.

Senior professional titles have prominent advantages around all research personnel, whether in terms of resources acquisition or outputs. 58% of the scientific research personnel who have the senior professional title belong to the resource abundance type, 7% belong to the resource lack type; while 79% of the entry-level or no title personnel belong to the resource lack type, and 3% belong to the resource abundant type. The average number of published papers of the four professional title groups are 7.9, 4.6, 2.3 and 0.9, respectively. The numbers of published papers are cut in half by each title, from senior to entry-level.

To occupy the management position also has obvious advantages. In respect of research resources acquisition, 47% managers and only 25% general staff belong to the abundant resources. The former is about 2 times than the latter; in the aspects of scientific outputs, the average number of published papers of managers is 6.0, while general staff is 4.1 in 2007-2009. The former is about 1.5 times than the latter.

B. Non-individual factors

In respect of research resources acquisition, the percentage of universities research personnel who do not host research projects is 22%, while the percentage of research Institutes is 48%. In terms of research outputs, the average number of papers published of universities research personnel in 2007-2009 is 5.5, while the research institutes' is 2.7. The former is about 2 times than the latter.

Scientific research personnel in danwei which has a Ph.D. program has a clear advantage. If danwei has a Ph.D. program, 41% research personnel will belong to the resource abundance type, and the average number of published papers will be 5.9; if danwei does not have the Ph.D. program, and then the two indicators will be 18% and 3.2 respectively.

The east region has an advantage over the center and west regions. In the east, center and west regions, the proportion of scientific research personnel belonging to resource abundance type are 35%, 22% and 26%, respectively; the average number of published papers is 5.1, 3.3 and 4.3, respectively. Interestingly, the center region is not only weaker than the east region, but also appears to be inferior to the west region.

TABLE 1. DESCRIPTIVE STATISTICS FOR THE SAMPLES OF SCIENTIFIC RESEARCH PERSONNEL

independent variable	Category	Sample proportion (%)	RES(%)			Paper published(papers)	
			Abundant type	Medium type	Lack type	mean	5%trimmed mean
gender	male	65	33	37	30	4.8	4.2
	female	35	19	44	37	3.5	2.9
education	doctor	38	48	43	10	7.6	7.3
	master	34	16	46	38	2.7	2.3
	B.A. or under	29	18	28	54	2.1	1.5
Professional title	senior	24	58	34	7	7.9	7.7
	sub-senior	36	32	43	25	4.6	4.0
	junior	31	8	45	47	2.3	1.9
	entry-level	9	3	18	79	0.9	0.6
Administrative position	managers	15	47	36	17	6.0	5.5
	general staff	85	25	40	35	4.1	3.4
danwei	research institute	40	27	25	48	2.7	2.1
	university	60	29	49	22	5.5	4.9
Ph.D. program in danwei	none	56	18	43	39	3.2	2.6
	yes	44	41	35	24	5.9	5.4
Region	east	42	35	38	28	5.1	4.5
	center	30	22	42	36	3.3	2.7
	west	28	26	40	34	4.3	3.7
Total		100	29	40	32	4.4	3.7

V. REGRESSION ANALYSIS RESULTS

A. Multi-nominal Logistic Regression Analysis Results

In the multi-nominal Logistic model, we take RES=3 (the lack type) as the reference group and use age, gender, education, professional title, administrative position, danwei type, Ph.D. program status and the area of danwei as independent variables. The relationship among research resources acquiring and independent variables have been analyzed. Table 2 presents the results of logistic regression.

First, in the field of acquiring research resources, research personnel individual difference is not significant. Age is not a significant determinant of research resources acquisition. Gender has contributed to affect research resources acquisition, but it is not a linear relationship. Male researchers are significantly more likely to be the abundant type than female, but male and female researchers do not differ significantly in the likelihood of becoming the medium type.

Second, academic ability and administrative position difference of research personnel have significant impact on acquiring research resources. Both education attainment and professional title, which can reflect a person's academic ability, have greatly contributed to affect research resources acquisition. Research personnel who attain higher education are significantly more likely to acquire resources than lower education ones, and research personnel who have the senior title (such as professor) are significantly more likely to acquire resources than entry-level ones. Administrative position also has a significant impact on resources acquiring. People who has middle or above administrative position are significantly more likely to acquire resources than whom has no administrative position.

Third, the research conditions and capacity have significant impacts on resources acquiring. Comparing with research personnel in universities, people who work in the research institutes are more likely to be the abundant type as well as the lack type, but less likely to be the medium type. It means that the researchers in research institutes will occur polarization rather than equalization when acquiring research resources. Research personnel working in the danwei which having Ph.D. program are significantly more likely to acquire resources than the researchers whose danwei has none Ph.D. program. Additionally, research personnel working in east region are significantly more likely to acquire research resources than those in west region. Because the research conditions and capacity of east region are better than west region, generally.

TABLE 2：SUMMARY OF MULTI-NOMINAL LOGISTIC MODEL FOR RESEARCH RESOURCES ACQUISITION (REFERENCE GROUP=THE LACK TYPE)

	Abundant type			Medium type		
	B	significant level	Exp(B)	B	significant level	Exp(B)
intercept	-4.424	0.000	0.000	-0.039	0.908	0.000
age	-0.008	0.428	0.992	-0.030	0.000	0.971
gender=male	0.399	0.001	1.491	-0.110	0.246	0.896
education=doctor	2.193	0.000	8.965	1.349	0.000	3.853
education=master	0.682	0.000	1.979	0.543	0.000	1.722
professional title=senior	4.714	0.000	111.452	2.899	0.000	18.161
professional title=sub-senior	3.007	0.000	20.232	1.761	0.000	5.820
professional title =junior	1.094	0.003	2.986	1.045	0.000	2.844
administrative position =manager	0.646	0.000	1.908	0.487	0.002	1.627
danwei=research institute	0.410	0.002	1.507	-0.982	0.000	0.374
Ph.D. program=Yes	0.600	0.000	1.822	-0.378	0.000	0.685
Region=east	0.444	0.001	1.559	0.108	0.344	1.114
Region=middle	-0.125	0.403	0.883	-0.091	0.441	0.913

Note：Taking the lack type as the reference group，Chi-Sq=1766, df=24，P=0.000. The reference groups of the dummy variables are as below：Gender=female, education=B.A. or below, professional title=entry-level or none, danwei=university, Ph.D. program =no, region=west.

B. Multiple Linear Regression Analysis Results

In the linear regression model, we take the number of published papers as dependent variables and represent the scientific outputs, and set age, gender, education, professional title, administrative position, danwei type, Ph.D. program status and the area of danwei as independent variables. The relationship among scientific outputs and independent variables has been analyzed. The results are presented in Table 3.

First, there is a significant correlation between resources acquisition and research outputs, that means the more resources are acquired, the more the number of published papers. This result is in line with the input-output proportional law.

Second, research personnel individual and administrative position difference are not significant in the field of scientific outputs. Age has little effect on the number of published papers, and the effect of gender on the number of published papers is also not significant. The effect of administrative positions on the number of papers published is not significant.

Third, the academic ability difference of research personnel has a significant impact on scientific outputs. The higher education level ， the more published papers. The impact for doctoral degree on the number of published papers is very significant, but the role of master's degree is not significant. The higher professional title, the more published papers, and the role of senior title is particularly evident.

Fourth, the research conditions and capacity have significant impacts on scientific outputs. Compared to the research institutes, the research personnel of universities are more productive, and the difference between universities and research institutions is statistically significant. Similarly, if a danwei has a Ph.D. program, the number of published papers are significantly more than those danwei which has no Ph.D. program. However, in the field of regional differences, the difference between the research personnel of the east region and the west region is not significant, while the center is obviously weaker than the west.

TABLE 3：SUMMARY OF LINEAR REGRESSION MODEL FOR PAPER PUBLISHED

independent variable	B	S.E.	Beta	Sig.
constant	0.995	0.555	-	0.073
research resources acquisition = abundant type	2.419	0.234	0.206	0.000
research resources acquisition = medium type	1.002	0.194	0.092	0.000
age	0.004	0.013	0.006	0.764
gender=male	0.262	0.157	0.024	0.096
education=doctor	3.157	0.249	0.288	0.000
education=master	0.390	0.216	0.035	0.071
professional title=senior	3.230	0.414	0.260	0.000
professional title=sub-senior	0.921	0.339	0.083	0.007
professional title=junior	0.119	0.299	0.010	0.691
position =manager	0.130	0.217	0.009	0.549
danwei=research institute	-0.946	0.176	-0.087	0.000
Ph.D. program=Yes	0.365	0.165	0.034	0.027
region=east	0.088	0.182	0.008	0.628
region=middle	-0.809	0.194	-0.070	0.000

Note：R^2=35%. The reference groups of the dummy variables are as below：Research resources acquisition =lack type, gender=female, education=B.A. or below, professional title=entry-level or none, danwei=university, Ph.D. program =no, region=west.

VI. CONCLUSIONS

This study is based on a Chinese nationwide survey named “Status of Chinese research personnel undertaking research projects”. Three main conclusions can be drawn from the statistical analysis results: first, in the field of science and technology in China, the principle of universalism is still the main operating rules. The high level talents with higher professional title and higher educational background will get more research resources, as well as gaining more research outputs. Second, some special principles also play a certain role, such as administrative positions, gender and other factors. These factors affect scientific research personnel’s ability to acquire research resources, but have no effect on outputs. Third, region, danwei and other macro factors constitute a constraint or guidance for scientific research personnel.

The analysis results verified the validity of this study’s hypothesis. That means if you want to get more scientific outputs, you need to improve your academic ability to acquire more research resources. Because this study is based on 5554 valid questionnaires nationwide, these analysis results may represent the status of developing countries like China.

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