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# What are the major impact factors on research performance of young doctorate holders in science in China: a USTC survey

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**Abstract** Doctoral graduate research performance (DRP) is recognized as one of the most critical indices for evaluation of the success of doctoral education. Doctoral graduates with high research performance directly reflect a higher ability in academic research and academic achievement. Consequently, identifying which factors influence DRP is potentially of great value. This topic is also challenging because of difficulties in identifying the impact factors on research performance and the feasibility of the relative data collection. This paper first examines the relationships between the indicators and DRP. After a review of previous literature, the focus is on the doctoral graduates' individual factors, advisor factors and learning performance. Data is collected from graduated doctors from the Science Schools of University of Science and Technology of China (USTC). Contrary to expectations, our findings indicate that, based on the Chinese context, learning performance does not appear to be strongly associated with research performance. Individual factors (status of academic origin) do have significant effect on DRP. The advisor factors (including academic status, academic experience and allocation of energy) show a relatively strong association with DRP, in terms of both the number of publications and the impact factor of Science Citation Index (SCI) cited journals.

**Keywords** Doctoral graduate · Research performance · Individual factor · Advisor · Learning performance

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## Introduction

Representing the highest degree in education, doctoral education is increasingly considered to reflect the success of a university, which, in turn, will enhance overall national recognition and achievement. Historically, Doctoral Graduates' Research Performance (DRP) has directly reflected the quality of doctoral education. As China has embarked on enhancing its international competitiveness, more and more doctoral programs have been implemented in Chinese universities. Therefore, exploring the influential factors of DRP can help us identify the major impact factors on doctoral education; further, suggestions about how to improve the doctoral education can be obtained.

The DRP refers to the performance of research participators in a certain period. This performance is determined by the capacity for research, including the doctoral graduates' competency in problem-identification, information processing, data collection, independent analyses, carrying out empirical investigations or experiments, academic writing abilities, and so on. However, compared with other abilities, DRP is more difficult to measure due to its complexity. In prior research, the influential factors of DRP have not been systematically embodied in China, leading to an inadequate understanding of this topic. Given the unique cultural background of China, including shared values and attitudes, the studies that have been carried out in the western environment would be inappropriate to apply to the doctoral educational practices in China today. Since only a limited number of studies have considered the DRP in the Chinese context, filling this gap could be of great value to improve doctoral education in Chinese universities.

The assumptions that organisational science hold regarding the contents of the educational processes influence the ways in which doctoral graduates are recruited, selected, and socialized, as well as how resources are allocated to support scholarly activities (Long et al. 1998). Therefore, our research question is: Do student individual factors and advisor influence make a difference, as illustrated in DRP?

A number of universities and colleges in China have recently reformed their enrolling systems, such as giving advisors empowerment, to some degree, in choosing their doctoral graduates—an approach that has shown some positive results. As a result, how to detect these candidates to fit the future research need becomes a challenge for both the university and advisor. This research attempt to seek answers for our research question in order to help university officers and advisors not only to distinguish elite students with potential high research performance in the future from the others, but also to provide guidance for graduate school officers in designing favourable programs and improving management of advisors.

The rest of this paper is organised as follows. The next section comprises the literature review of the categorization of the factors used to predict doctoral graduates' research performance. The third section provides the theoretical framework and hypotheses. The fourth section describes the methodology, after which the results are reported in "Data analysis results" section. This is followed by a discussion of the results in "Discussion" section, the limitations and future research in "Limitations and future research" section, and conclusions in the final section.

## Literature review

### Research performance

Traditionally, performance is regarded as a single dimension concept referring to the actions of achievement and accomplishment in a certain target or task. The outcome of research plays a key role in developing and evaluating academic achievements of doctoral graduates referred to as research performance. Over the past decades, three types of approaches have been used to measure research performance in higher education: the quantitative, the qualitative approaches, and the comprehensive approach.

The most commonly used *quantitative approach* of measuring research performance is analysing the number of publications in selected outlets, such as academic journals (Baird 1991; Grigg and Sheehan 1989; Dundar and Lewis 1998; Reinstein and Hasselback 1997), or calculating comprehensive indices from counts of conference papers, journal publications, and books (Hartley et al. 2001). Studies focusing on publication counts have been criticised for several reasons. First, publication counts vary across disciplines due to the nature of the work being performed and the conventions for communicating research (Wanner et al. 1981). Second, they do not take into account the quality of publications (Braxton and Bayer 1986), except to the extent that they have passed through peer reviews (Manis 1951). But the quality of publications can be reflected by the quality of journals (Chen 2008), as it is assumed that publications in higher tier journals make a significantly greater contribution.

In response, some scholars have used the *number of citations* to measure individual research performance (Diamond 1986; Lindsey 1989; Laband and Piette 1994) and the impact factor of journals to reflect indirectly the quality of research productivity (Anseel et al. 2004; Jones 2003; Neuberger and Counsell 2002). Citation counts provide a quantitative expression of the utilization, acceptance and visibility of published research in international scientific literature and communication, so it could reflect the quality of publication (Moed et al. 1985). The founding of the Institute for Scientific Information (ISI) by Garfield has led to a burgeoning use of citation measure (Braxton and Bayer 1986). According to Garfield (1979), research production is measured by using indices based on the number of times publications are cited in journals covered by the Science Citation Index (SCI), which is produced by the ISI. Wallmark and Sedig (1986) suggest that one advantage of citation is its objectivity, because no manipulation can be made, since the investigating person or group does not actually participate in the research assessment.

However, this method has some limitations. First, there is the phenomenon of obliteration, which takes place when a scientist's work becomes so generic in the field and highly integrated into the body of knowledge that researchers frequently find it unnecessary to cite it explicitly. Second, the citation varies significantly from discipline to discipline and even from subject to subject in a given field. To cope with the aforementioned problem, the quality of journals (i.e., the impact factor) has been introduced recently to reflect one facet of research performance (Theoharakis and Hirst 2002), as it is assumed that publications in higher tier journals make a significantly greater contribution than do lower tier journal (Chen 2008). However, it is worth bearing in mind that the impact factor of journals would also be significantly different from discipline to discipline, and thus it is difficult to make comparisons between disciplines.

The *qualitative approach* includes the analysis of perceptions from peer-reviews, panel discussions, case appraisals, and so on. The advantage of perception analysis is the respondents' expertise and knowledge in related fields (Brown and Huefner 1994). However, peers from different cognitive domains may evaluate a given scientific contribution quite differently, as their evaluations can be influenced by their level of knowledge and research biases (Meho and Sonnenwald 2000). Perception analysis may also suffer from inherent respondent bias, such as self-serving and predisposition bias (Theoharakis and Hirst 2002).

However, neither the quantitative nor the qualitative approach by itself can be said to be best for evaluating research performance, and thus multiple criteria are warranted (Carter 2002). In a study of the evaluation methods of individual senior scholars, Meho and Sonnenwald (2000) found that quantitative methods (citation and bibliometric analysis) and qualitative methods (perception and peer-review) perform similarly.

The major challenges are how to deal with incomplete subjective or objective information and how to make use of the evaluations to improve the research performance (Zhou et al. 2001; Theoharakis and Hirst 2002). After considering the advantages and disadvantages of the previous approaches, we use both the number of publications and the impact factor of the journal to measure DRP. In greater detail, we compute the weighted number of published papers through the duration of a student's PhD studies, and the weighting as the impact factor of journals.

## Influential factors on DRP

In previous literature, researchers have examined the factors that most significantly influence the research performance of universities and faculties, but few have studied the influential factors at the doctoral students' level. Therefore, we focus on the doctoral graduates' individual factors, advisor factors and learning performance to study their influences on DRP.

It is clear that even with the same advisor, different doctoral graduates may have varying research performance; thus, there should be *individual factors* that influence DRP. Early work with easily identifiable factors includes the effects of age, gender, socioeconomic status, and educational background (Tien and Blackburn 1996; Roberts 1997; Fox and Mohapatra 2007). The racial factor can also be a significant one (Fosu 2006). Later, scholars started to study some valuable factors to better analyse research performance, but these factors could not be identified directly. Long et al. (1998) examined the relationship among the status of academic origin, academic affiliation, and research productivity of doctoral graduates. They discovered that the status of academic affiliation had a relatively strong association with research performance; however, the status of a graduate's academic origin did not appear to be strongly associated with research performance. Fox and Mohapatra (2007) studied the social-organisational characteristics of work, which was found to affect scientists' publication productivity.

As to the *advisor factors*, some scholars posit that advisors' research performance affects DRP (Shim et al. 1998). More recent studies on the relationship between the advisor factors and student's research performance focus on theoretical studies, but little on empirical analyses. Researchers in prior studies have identified the following factors as influencing advisors' research performance: interest in research (Blackburn et al. 1978), the allocation of time to research activities (Chow and Harrison 1998; Bucheit et al. 2001), tenure status (Chow and Harrison 1998; Yoakum 1993), length of the tenure probationary period (Chow and Harrison 1998), teaching load (Chow and Harrison 1998), and financial research support (Chow and Harrison 1998). In addition, Shim et al. (1998) argue that social psychological factors, such as support from colleagues and administrators, reinforce or improve the research performance of faculty.

*Learning performance* is another category to be considered, as it can reflect different levels of doctoral students' success in learning activities. Gelso (1979) proposes that improving research training is the most useful way to increase research performance. Empirical studies show that, compared to doctoral graduates with low learning performance, those with high learning performance are more prepared for getting published

(Royalty and Magoon 1985). Thus, those with high learning performance are expected to perform better in research activities.

Based on the review of literature, we found that most of studies focused on the research performance of universities and faculties, but few have studied the influential factors at the doctoral students' level. Specially, much fewer studies about the influential factors of DRP had been systematically embodied in China, leading to an inadequate understanding of this topic. Given the unique cultural background of China, the approaches that have been carried out in the western environment would be inappropriate to apply to the doctoral educational practices in China today. Thus, we extend the existing literature on the chosen of research samples from Chinese universities and the impact factors of research performance by focusing on both of advisor's influence and individual factors which have been mostly excluded from studies of research performance at doctoral graduate level.

## Research model and hypotheses

Based on the literature review, we classify the influential factors into three categories: the individual factor, the advisor factor, and the learning performance factor. And we choose sub-factors to represent each category (shown in Table 1).

Then, we have developed a theoretical model (shown in Fig. 1) and the associated hypotheses. The basic premise of our hypotheses, as indicated in Fig. 1, we propose that student's individual factors and his or her advisor would have significant effect on research performance of doctoral graduate.

### Individual factors and research performance

As noted, empirical studies have found that individual factors are a significant determinant of research performance of entire institutes or faculties. There are several reasons for expecting such a relationship, and the influencing mechanism can be applied to individual factors of a doctoral graduate. We focus on individual factors that often reflect a strong relationship with research performance, namely: gender (Stack 2004; Milburn and Brown 2003), age (Hall et al. 2007; Milburn and Brown 2003), the original university graduated from (Long et al. 1998), and marriage status (Stack 2004).

**Table 1** DRP and influential factors

| Type of variables | Variables | Sub-factors |
|---|---|---|
| Dependent variable | Research performance | Number of publications |
| | | Quality of publications |
| Independent variables | Individual factor | Gender |
| | | Age |
| | | Academic origin |
| | | Marriage |
| | Advisor factor | Age |
| | | Academic experience |
| | | Academic status |
| | | Quantity of instruction |
| | Learning performance | Average score |

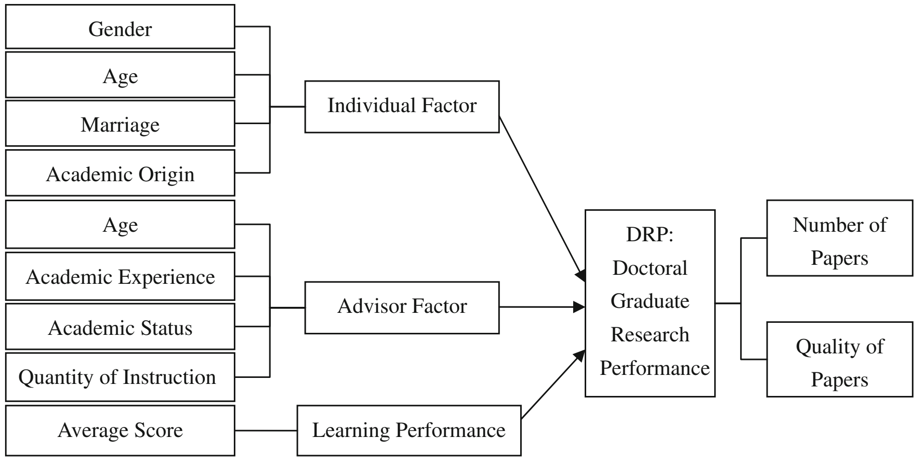


**Fig. 1** Theoretical model

A review of more than 50 studies concludes that male scientists publish nearly twice as much as do female scientists in the US (Cole and Singer 1991). This *gender* gap in research performance has been referred to as the "productivity puzzle" (Xie and Shauman 1998). It has been attributed to factors including: the greater parenting and marital responsibilities of women relative to men, women's difficulty in becoming integrated into the male dominated work and social milieu, more limited opportunities for co-authorship, discrimination, an alleged lower value being placed on research performance among women, lower research funding for research by women, a lower incidence of female appointments in top research-oriented universities, and a lower incidence of collaboration with graduate advisors among women (Fox 1999; Long 2001).

*Age* has a synthesized effect on research performance, with other factors being positive or negative (Milburn and Brown 2003). Wood (1990) suggests that age can be considered to have both negative and positive aspects. For example, Prpic (2000) surveyed 840 scientists and found that age was negative to their research productivity, but Canibano et al. (2008) verified that older scientists seemed to have more research publications. Specially, in our paper, as the samples are doctoral graduates from a Chinese university, the older students usually have to play more social roles, consequently his or her time and energy spending on research activities tend to be limited. Thus, we propose that the older the researchers are, the lower their research performance becomes.

The *status of marriage* is associated to the responsibility for the family one person would take. If one doctoral student has been married, he or she would be allocated to some family loads and burden. In addition, marriage would also bring with it the heavy responsibility for children. In an attempt to understand the impact of marriage on individual research performance, many researchers have focused on marital status (Astin and Davis 1985; Astin 1969, 1978). Research on the role of marital status factors in research productivity has produced mixed results. For example, while some studies (Astin 1969; Ogbogu 2009) have found that being married is negatively related to productivity for women, others (Hamovitch and Morgenstern 1977) found no such influence for either women or men. In China, the traditional value is that, if one person was married, he or she must be responsible for the family including relatives from both sides, and can not run away from trivia in life, so it would be unavoidable to disturb their participation in research activities. In this paper, we assume that doctoral graduates who are married would be interrupted their research to attend to family responsibility.

As to the *academic origin*, the high-status schools are more likely to reward research performance (Konrad and Pfeffer 1990; Long et al. 1998). Thus, those who study at high-status schools may accumulate advantages that would help them to gain high research performance (Bayer and Dutton 1977). In this paper, we code the academic origins of doctoral graduates as from inside or from outside. The academic origins from inside means that the doctoral graduates enrolled have finished the master or lower degree in the same university. And the academic origins from outside means that the doctoral graduates enrolled have finished the master or lower degree in other universities, including the national key university and common university.

Therefore, our hypotheses are:

**Hypothesis 1a** Male doctoral graduates will have higher research performance than will females.

**Hypothesis 1b** The age of doctoral graduates will have a positive effect on DRP; that is, the older the doctoral graduate, the lower the DRP.

**Hypothesis 1c** The marriage status of doctoral graduates will have a negative effect on the DRP.

**Hypothesis 1d** Doctoral graduates with upper-level academic origins, especially those with academic origin from inside, will have higher research performance.

### Advisor factors and the research performance

In general, most universities have adopted the system in which PhD candidates do research under one or more advisors (Delamont et al. 2000). Successful completion of a PhD depends on the quality of the supervision and the interaction between advisors and students (Denicolo and Pope 1994; Grant and Graham 1994; Delamont et al. 2000; Hill et al. 1994).

*Advisor age* could partly reflect how much energy and time the advisor spends in managing research, mentorship and related activities. Thus, older advisors may have less energy and time than do younger ones. The graduates of PhD programs with more active faculty would publish more total journal articles (Hogan 1981), since advisors devote much time and effort in teaching and helping doctoral students. This could result in students receiving improved training, and, accordingly, exhibiting higher performance.

And with increasing *research experience*, advisors' research productivity would accumulate (Brewer et al. 1999; Bentley and Blackburn 1990), and doctoral graduates would benefit from their advisors' academic experience. Advisors with rich academic experience not only have greater ability in research and an improved research methodology, but also have more advanced education concepts, better teaching methods and improved skills in educating students.

Age and experience are interwoven, since the older advisors tend to have more experiences that expose them to more advanced education concepts, thus they become more resourceful and effective in teaching for the following reasons:

1. Age and experience do not necessarily have a linear relationship. Some advisors got their professor position much earlier than their peers, thus advisors with similar age would have diverse research experience.

2. The age has independent influence on the mentoring style, because advisors with various levels of age would have different life experience, social skills, psychological status, work inspiration, energy, work time and efficiency.
3. The older advisor may have less energy and inspiration but more patience and social skills than the younger, but the overall effect we assume is that the younger advisors may be more efficient in mentoring.

Thus, we give the following hypothesis.

**Hypothesis 2a** The age of advisors will have a negative effect on DRP: the older the advisor, the lower the DRP.

**Hypothesis 2b** Advisors with more academic experience will produce doctoral graduates with greater research performance.

The *academic status* of advisors would partly reflect ability in research and research productivity, as well as represent research area influence. Yoakum (1993) indicates that the tenure status and higher academic rank directly relate to research performance.

Several scholars have argued that in order to improve DRP, universities should employ and retain faculty members who are productive researchers (Ventriss 1995). The reason is that these faculty members are more capable of training doctoral graduates to conduct research, since the advisors will have greater ability to teach, guide and collaborate with students, which, in turn, will have a significant positive influence on DRP (Whitely et al. 1991). Thus, we hypothesise that:

**Hypothesis 2c** Advisors with the upper-level academic status educate doctoral graduates with greater research performance than do advisors with lower-level academic status.

The success of *instructions* the advisors give to doctoral graduates mainly depends on face-to-face meetings. If doctoral graduates frequently meet with their advisors, they tend to be given more instruction. Heath (2002) surveyed 355 PhD candidates at the University of Queensland, and the results of descriptive analysis showed that the more frequently PhD students met with their advisors, the more support they were given by advisors; as a result, PhD students published more papers and gained improved research ability. Thus, we propose that:

**Hypothesis 2d** The lower the quantity of instruction of doctoral graduates, the lower their research performance.

## Learning performance and research performance

*Learning performance* shows that teacher put effort to teach the curriculum and the doctoral graduate study hard to acquire both the knowledge and skills, which are useful for doctoral students to better perform in their subsequent research activities. Previous literature shows that learning performance has a significant effect on DRP. Ferris and Stallings (1988) have found that individual efforts are positively related to research performance, and that the learning performance can partly reflect doctoral graduates' efforts. Based on this rationale, some programs use student Grade Point Average (GPA) to evaluate learning performance. In the Chinese education system, universities take the average score of courses as the key index for evaluating students, and this is of vital importance to enrolment and scholarship. Thus far, there are few empirical studies that evaluate whether a doctoral graduate with better learning performance shows better performance in research activities. To analyse the influences of learning performance on DRP, we propose our last hypothesis:

**Hypothesis 3** Learning performance will have a positive impact on the DRP.

## Research methodology

### Independent variables

In this paper, we choose the individual factor, advisor factor, and learning performance as independent variables in our model.

### Individual factors

The individual factors consist of gender, age, academic origin, and marriage, among which gender and marriage are coded as binary variables. The range of learning years is usually from three to 5 years, but sometimes more than 5 years; thus, we take the entry time as the datum mark, and the identifying age as:

$$Age = \text{“Year of entering”} - \text{“Year of birth”}$$

The academic origin is treated as a nominal variable indicating whether the individual is either from inside or outside. The academic origin from outside are classified as the national key university and common university, which based on the classification by the Ministry of Education (MOE) of China.

### Advisor factors

To measure the advisor factors, we consider both advisors' ability to do research and personal characteristics. It is challenging to measure the advisor factors due to the complexity of the index and the difficulties of making quantitative measurements. To cope with the problem, we choose the advisor's age, academic experience, academic status, and quantity of instruction to measure advisor factors.

First, age can be an important determinant of advisors' ability to conduct academic research. On the one hand, professors' experience tends to enrich as they age; on the other hand, older professors may have less energy than do younger ones in managing research, mentorship and related activities. In this paper, the age of advisors is identified as:

$$Age = \text{“Year of doctoral graduates entering”} - \text{“Year of birth”}$$

Second, with increasing research experience, advisors' research productivity accumulates (Brewer et al. 1999), and doctoral graduates would benefit from their advisors' academic experience. We assume that the number of years since the time that an advisor became a professor can express his or her academic experience, which can be identified as:

$$Academic\ experience = \text{“Year of doctoral graduates entering”} - \text{“Year of becoming professor”}$$

Third, we use the advisors' academic status to evaluate their ability in conducting research because the main way of elevating their status is having good performance in academic research. In China, the upper-level academic status includes the Science

Academician,[1] the Excellent Young Scholar,[2] and the Yangtze River Scholar[3] (awarded by National Science Foundation of China, NSFC). In this paper, we define lower-lever academic status as that outside the above-mentioned three upper-levels. Thus, academic status is measured as binary variables: (0, 1), where 1=upper-level academic status, 0=lower-level academic status.

Last, the energy that advisors expend on research and teaching is finite and needs to be divided among all students. A popular viewpoint is that the more time advisors spend on doctoral graduates, the better their research performance will be. We assume the number of doctoral graduates will have negative effect on the energy and attention spent on each doctoral graduate. Therefore, by taking the quantity of instruction as a variable in advisor factors, it is measured by the total number of supervised doctoral graduates, which could be negative to allocations of energy and inversely related to the amount of attention each one is given.

### Learning performance

Compared with other education systems, developing DRP is the main goal of doctoral programmes. There are many courses for preparing doctoral graduates. Students' learning performance reflects the success of learning and their readiness for doing research.

In order to measure learning performance, we choose the average score to represent it. Although the time a doctoral student spends on learning activities is qualitative and circumstantial, the average score is viewed as a good measure for students' knowledge and skills gained while at university. In Chinese doctoral programmes, compulsory courses and public elective course are offered. Some courses are subjected to exams, whereas others are tested by class participation; however, both types of courses give students the final scores. Therefore, we use the average score of both compulsory courses and public elective courses in all stages of the doctoral programme to quantify the learning performance.

### Dependent variable

In this paper, we take DRP as the dependent variable. The research performance is measured in relation to the quality of research. After considering the advantage and disadvantage of previous approaches, we consider using both quantitative and qualitative methods to measure DRP. We adopt the view that many scientists hold: "The higher the impact factor of the journal in which a paper is published, the more impact the paper may have". A standardized method to calculate the quality of journals is to use the impact factor developed by Garfield (1979) at the Institute for Scientific Information. The impact factors were designed to provide an objective comparison among journals (Neuberger and Counsell 2002). The definition of the impact factor of a journal is the average impact of all papers published in that journal during the last 2 years divided by the time of estimation. The formulation of the impact factor is as follows:

$$IF = CIT/PUB$$

[1] In China, 81 scientists were first awarded Science Academician by NSFC in 1948.

[2] The award of Excellent Young Scholar began in 1994 by NSFC; its purpose is to attract overseas Chinese and foreign students to come back to the motherland.

[3] The award of Yangtze River Scholar is carried by NSFC in 1998; its purpose is to cultivate outstanding scholars and improve the quality of higher education.

where *IF* is the impact factor of the journals. *CIT* is the number of cited article in a given journal over the preceding 2-year period. *PUB* is the total number of articles it published over the preceding 2-year period.

It is frequently accepted that this reflects the likelihood that a paper will have an impact. Impact factor is one way to gauge the relative importance of a journal compared to others in its field.

Therefore, in our study, we use both the number of papers and the impact factor of the journal to measure DRP. For greater detail, we compute the weighted number of published papers through the duration of a PhD student's study, and the weighting as the impact factor of journals. The formulation of DRP is that:

$$DRP = \sum_{i=1}^{n} IF_i$$

where $i$ represents the paper $i$ that has got published; $IFi$ is the impact factor of the journal in the year paper $i$ published; $n$ is the total number of papers published during the period of one's PhD studies.

## Data collection

To test our hypotheses, we collected data on doctoral graduates who had graduated from a major university located in eastern China: the University of Science and Technology of China (USTC). Samples were selected from PhD students who had graduated from the school of Science in USTC, majoring in Physic and Chemistry. Based on our observation, doctoral students from these two fields have similar academic backgrounds; however, they are also reasonably heterogeneous, given that they have unique individual information, different research performance, and have been instructed by a number of different advisors. Since they have already graduated, it is reasonable to expect that they have reached a certain level of research performance.

The information of doctoral graduates was collected from the recorded files in the office of the graduate school in USTC. The records contain the student's date of birth, marriage status, gender, and graduated university. They also contain advisors' information, such as their resumes, with the date of birth, academic status, and the year of becoming a professor. Learning performance is measured by the average score on course exams recorded in the database. Altogether there are 136 graduated doctors enrolled between 2002 and 2003, and 37 of their advisors in the School of Science in USTC were chosen.

To collect data for the measurement of the DRP, we compiled publication records for the sample of 136 graduated doctors who had published papers during their PhD studies. The proxy for research quantity was the unweighted count of journal articles from Chinese databases (such as CNKI),[4] English databases (such as Scholar OA),[5] and some famous searching networks (such as Google, Baidu). Data regarding each paper were recorded as follows: (1) the journal's name, (2) the field of the journal, and (3) a code denoting whether the journal is included in Science Citation Index (SCI) database. We identified more than 1,100 papers published by members of the sample.

[4] The full name for CNKI is China National Knowledge Infrastructure. The databases of CNKI are the largest academic journals database in China, and the greatest Chinese database in the world.

[5] The full name for Scholar OA is Scholar open access.

The SCI is used as reference for the impact factor of the journal in which the paper was published. We identified more than 300 journals in the field of science cited by SCI database. We computed the average impact factor of each journal over 2 years, 2002 and 2003, as the weighed counts of journal articles. The choice of average impact factor of journals was affected for two reasons:

1. *Publication has a time-lag effect* because a paper has to wait for a considerable time from its submission to its appearance in the journal. Compared with the impact factor of the journal in the published time, the submitted time is appropriate and rational, and reflects precisely the quality of the publication.
2. *Stability of the impact factor in the last 2 or 3 years.* Through observing the impact factors of some journals in the last 3 years, we found that the impact factor of one journal did not exhibit the same abrupt changes in the numerical value, except for new journals (that is, the total publication time was less than 3 years).

Since the samples were from the School of Science, in the process of data collection, we found that more than 98% of the collected papers were in English, and that more than 90% of the collected papers were published in SCI cited journals. Therefore, we computed only the papers cited by SCI to measure DRP, and collected the impact factor of journals of various fields from the online SCI database (http://www.thomsonscientific.com/mjl/).

## Data analysis results

In this research, the empirical analysis is generated from the descriptive analysis and regression analysis, using SPSS11.5 as the statistical analysis software tool.

### Descriptive analysis

The results of the descriptive analyses (Tables 2, 3) show that the mean weighted count of papers is 15.24, the minimum and maximum being 0.41 and 122.84, respectively. However, the standard deviation was 17.66, indicating that the DRP among doctoral graduates varies considerably, and thus we explore the influential factors to explain this difference. Next, we classified the sample by gender, for females the mean weighted count of papers published was 24.86, and for males it was 14.05—comparatively lower.

### Regression analysis

Table 4 provides the results of a series of linear regression analyses. First, we examined the samples and variables to see whether they satisfied the basic condition of regression. We examined the multi-collinearity (Table 4) and the variance inflation factor (VIF), the results of which showed that the maximum VIF is 1.638 and the mean of VIF is 1.402; thus, multi-collinearity is not a problem. We also examined the autocorrelation. The Durbin-Watson (DW) was 1.529, indicating that there was no autocorrelation between independent variables in the model.

In the model, the positive coefficient indicates that an increase in the value of variables contributes to a larger weighted number of papers, and vice versa. Since the residuals of all the regressions suffered from hetero-skedasticity, the $t$ statistics were corrected using White's (1980) consistent covariance matrix.

**Table 2** Result of descriptive analysis

| Measures | Items | *N* | Percent |
|---|---|---|---|
| Individual information ($n = 136$) | | | |
| Gender | Female | 15 | 11 |
| | Male | 121 | 89 |
| Age | 20–25 | 91 | 66.9 |
| | 26–30 | 34 | 25 |
| | 31–35 | 5 | 3.7 |
| | 36–40 | 5 | 3.7 |
| | 41–45 | 1 | 0.7 |
| Academic origin | Inside | 80 | 58.8 |
| | Outside-key university | 23 | 16.9 |
| | Outside-common university | 33 | 24.3 |
| Marriage | Married | 66 | 48.5 |
| | Not married | 70 | 51.5 |
| Advisor information ($n = 37$) | | | |
| Academic status | Upper-level status | 11 | 29.7 |
| | Lower-level status | 26 | 70.3 |
| Age | 20–30 | 1 | 2.7 |
| | 31–40 | 4 | 10.8 |
| | 41–50 | 11 | 29.7 |
| | 51–60 | 10 | 27.1 |
| | 61–70 | 11 | 29.7 |
| | **Min** | **Max** | **Mean** |
| Academic experience | 2 | 22 | 9.48 |
| Quantity of instruction | 1 | 28 | 6.19 |

**Table 3** Result of descriptive analysis—DRP ($n = 136$)

| | | Mean | Minimum | Maximum | Std. deviation |
|---|---|---|---|---|---|
| Research performance: weighted counts of paper | Total | 15.24 | 0.41 | 122.84 | 17.66 |
| | Female | 24.86 | 1.84 | 92.36 | 29.17 |
| | Male | 14.05 | 0.41 | 122.84 | 15.44 |

In our model, when all independent variables are included in the regression, the results clearly show that the positive and significant coefficients of variables are academic origin, advisor's academic experience, and advisor's academic status. The results also illustrate that the negative and significant coefficient variable is the quantity of instruction for doctoral graduates. However, the effect of learning performance is not significant.

Among the standardized regression coefficients, the variable most heavily tied to the variation in DRP is the quantity of instruction B4 (−0.342), followed by the advisor's academic status B3 (0.279), the advisor's academic experience B2 (0.276) and academic origins-inside A4 (0.221). The results indicate that when enrolling doctoral Science graduates from USTC, or assigning students with advisors in the upper-level academic

**Table 4** Result of regression

| Measure | Items | Unstd. coef. | Std. coef. | *t* (Sig.) | VIF |
|---|---|---|---|---|---|
| Individual factor | Constant | −18.784 | | −0.663(0.509) | |
| | Gender (A1) | −7.999 | −0.142 | −1.704(0.091) | 1.145 |
| | Age (A2) | −0.404 | −0.080 | −0.890(0.375) | 1.311 |
| | Marriage (A3) | 1.964 | 0.056 | 0.664(0.508) | 1.158 |
| | Academic origin (A4) | | | | |
| | Inside | 7.884 | 0.221 | 2.167(0.032)* | 1.697 |
| | Outside-key university | 3.203 | 0.068 | 0.714(0.477) | 1.499 |
| Advisor factor | Age (B1) | 0.143 | 0.070 | 0.729(0.467) | 1.498 |
| | Academic experience (B2) | 0.915 | 0.276 | 3.042(0.003)** | 1.354 |
| | Academic status (B3) | 10.189 | 0.279 | 2.794(0.006)** | 1.638 |
| | Quantity of instruction (B4) | −0.831 | −0.342 | −3.475(0.001)** | 1.583 |
| Learning performance (C) | | 0.394 | 0.130 | 1.558(0.122) | 1.136 |

Model summary

| $R^2$ | Adjusted $R^2$ | Sig. | D.W. |
|---|---|---|---|
| 0.237 | 0.176 | 0.000 | 1.529 |

ANOVA

| | Sum of squares | *df* | Mean square | *F* | Sig. |
|---|---|---|---|---|---|
| Regression | 9993.504 | 10 | 999.350 | 3.891 | 0.000** |
| Residual | 32102.917 | 125 | 256.823 | | |
| Total | 42096.421 | 135 | | | |

* Significant at 0.05; ** significant at 0.01

status, the DRP was higher, that is: the greater the academic experience of advisors, the higher the DRP; however, the lower the quantity of instruction for doctoral graduates, the lower their research performance. In this regression model, the adjusted multiple coefficient of determination is 0.176, indicating that the model as a whole explains approximately 18% of the variation in DRP.

Based on the results of regression analysis, we found that some assumptions are supported, however, some are not (shown in Table 5).

## Discussion

The present study provides systematic analysis of the influential factors on the DRP in the Chinese context. We first explore the factors with potential impact on the DRP, and then focus on the individual factors, the advisor factors and the learning performance. Based on the chosen factors and the indices of measuring DRP, we then use regression analysis to test hypotheses to see if there are significant relationships with DRP. Some independent variables are related to DRP as originally expected, but not all achieve statistical significance.

**Table 5** Findings

| | | |
|---|---|---|
| H1(a) | Male doctoral graduates will have higher research performance than will females | Not supported |
| H1(b) | The age of doctoral graduates will have a positive effect on DRP; that is, the older the doctoral graduate, the lower the DRP | Not supported |
| H1(c) | The marriage status of doctoral graduates will have a negative effect on DRP | Not supported |
| H1(d) | Doctoral graduates with upper-level academic origins, especially those with academic origin from inside, will have higher research performance | Supported |
| H2(a) | The age of advisors will have a negative effect on DRP: the older the advisor, the lower the DRP | Not supported |
| H2(b) | Advisors with more academic experience will educate doctoral graduates with greater research performance | Supported |
| H2(c) | Advisors with upper-level academic status educate doctoral graduates with greater research performance than do advisors with lower-level academic status | Supported |
| H2(d) | The lower the quantity of instruction of doctoral graduates, the lower their research performance | Supported |
| H3 | Learning performance will have a positive impact on the DRP | Not supported |
| Other findings (Sequence of the antecedents, from more significant to less significant) | | |
| Individual factors | Academic origin | |
| Advisor factors | Academic experience, academic status, quantity of instruction | |

As to individual factors, we find that age, gender and marriage status have no significant effect on the DRP. Possible reasons for this are:

1. *Limitation of samples.* The range of doctoral graduates' age is small, with 92% of the sample concentrated between 20–30 years, 67% from 20–25 years, and 25% from 26–30 years. Regarding gender, 89% are male. Due to the limitation of the samples, the conclusion may only partly reflect the reality. It is surprising, however, to see that the performance of females is almost double that of males. The hypothesis that males are more productive is certainly not supported, and these results may reflect a changing dynamic when more and more female doctoral graduates become elite in terms of publication performance.
2. *Traditional values and attitudes in China.* In Chinese culture, which is affected by traditional beliefs, males have higher motivation to complete advanced education, such as a PhD degree. On the other hand, most women focus more on social responsibilities for taking care of the family. As a result, most women have to abandon their hopes for accomplishing a PhD degree.
3. *Expectations of Chinese parents.* In China, youngsters' foremost mission is to acquire degrees to fulfil their parents' expectations. Most students (51.5%) are not married because they use their efforts and resources to gain knowledge and skills, instead of getting married. Those who are married may delay the birth of their babies so that they can concentrate on their PhD studies. Therefore, in the samples there is no significant difference in time spent in research activities.

The results also show that the age of advisors has no significant effect on DRP. The possible explanation here is that younger advisors are full of energy and motivation for research activities. It makes sense that at younger ages their research performance increases; however, once they reach a certain point, their research performance begins to decrease. With increasing age, the variance of a person's energy is parabolic rather than linear, and there is an inflexion. Therefore, the relationship between the age of advisors and DRP should be explored in the future.

A valuable finding is that learning performance in terms of the average score in the statistical analysis of all exams has no significant effect on DRP. This result indicates that learning performance is not of great benefit to DRP in the sample university (USTC). To explain this result, we seek some possible answers:

1. The high learning performance is indicative of a sample of doctoral graduates' success in learning activities, but does not reflect the performance in research. In China, most teachers and parents focus on students' learning performance, and take this as key criterion for evaluating students' success. As a result, students put much effort into attaining high scores in tests; maybe this has left students with limited attention for their research performance. To some extent, these above reasons possibly caused that learning performance had not an effect on DRP.
2. In China, the problem of higher education is that traditionally little attention has been placed on cultivating students' creativity and innovation, both of which are crucial to DRP. Through reform in the education system, this problem has been reduced; however, reform is a long-term project and cannot be realized in a short time. Since the problem is on-going, the learning performance does not have a significant effect on DRP.
3. Being in the highest level of the education system, the nature of doctoral education is different from that of other levels of education. Before doctoral graduates begin their research activities, they have already obtained basic knowledge and skills from previous education. Thus, the main objective of doctoral education is to cultivate research ability and help students to specialize in highly practical or applied research projects. Both abilities are developed from interaction with advisors rather than from taking courses. Thus, the advisor's academic experience and ability become critical to DRP, while the curriculum becomes less important.

For the above reasons, the learning performance does not have a statistically significant effect on DRP. In the regression model, the academic origin of doctoral graduates has a significant effect on DRP; especially graduates from USTC have a higher research performance. The possible explanations are as follows: (1) USTC is a top university in China and has better research strength, and therefore the samples from USTC will be elite; (2) doctoral graduate students have already adapted to the teaching style and research environment, and thus can quickly fit into the research activities. The results provide considerations for universities in the enrolment procedure, indicating that universities should consider students' academic origins while following up with plans to help new students to adapt to their new environment.

An important finding is that the advisor factor has the most significant effect on DRP, including academic status, academic experience and quantity of instruction. The results indicate that by following advisors with more academic experience and upper-level academic status, doctoral graduates will have higher research performance since both factors reflect advisors' ability in research. Accordingly, doctoral graduates will benefit from their advisor's considerable research experience and will have more opportunity to receive guidance in conducting research, along with useful advice. These results indicate that advisor's experience is crucial to the quality of higher education, and thus the university and ministry of education should make an effort to strengthen the staff quality by bringing in more excellent scholars.

In this paper, where we use the total number of doctoral graduates of each advisor to measure the quantity of instruction for every student, we find that the larger the number, the lower the DRP. This suggests that when the quantity of instruction for each doctoral graduate is greater, they will be more motivated to do research, and as a result, they will produce more research outputs. This finding, however, deserves additional discussion. The range of 1–28 students per advisor in this sample is very large and suggests that there is likely a zone of optimality in terms of students per advisor. The scope of this study takes into consideration advisor style, as well as student cohort effects and research stream collaboration, which may also impact productivity.

## Limitations and future research

As with all research, there are limitations to this study. First, caution needs to be taken in interpreting the results, since this study is based on a limited range of subjects in a single discipline—the physics and chemistry in natural sciences. Because natural scientists generally achieve considerably more citations than do social scientists, the results might not be generalizable to the social sciences and other fields. Second, in the regression model the adjusted *R* square is 0.176, indicating that the model as a whole explains approximately 18% of the variation in DRP. The reason may be that we focused mainly on demographic factors and quantitative ones that might have had an effect on DRP, without taking into consideration the psychosocial factors and personality. These factors could have exerted a significant impact on DRP. Therefore, to increase the variance explained, we could add other predictors into the model.

Based on the limitations described above, a possible direction for future research would be the exploration of the link between influential factors and DRP, controlling for personality of doctoral graduates. In particular, personality traits and internal factors (e.g., enthusiasm for research, motivation, time-management, social network, intelligence quotient, emotional quotient, extroversion and introversion) may be better predictors for DRP, as the present study has not addressed the issue of personality and internal factors as possible predictive variables for DRP. Thus, future work is needed on this issue, namely, investigation of the relationship between the DRP and some improved factors such as endogenous factors. The final target is to find out which influential factors are crucial and determinants of DRP. Because endogenous factors are qualitative and difficult to measure, interpretive approaches may enrich understanding, for example, in-depth interviews. Further, on the basis of relevant hypotheses, a theoretical model and further empirical analyses could be carried out.

## Conclusions

The aim of this paper was to explore which factors exert an impact on the DRP in China with participants taken from the doctoral graduates in the School of Science at USTC. The results of analyses could answer to the previous research question: Do student individual factors and advisor influence make a difference, as illustrated in DRP?

The results indicate that academic origin of doctoral graduates and advisor's academic status, academic experience, and quantity of instruction exert a significant impact on DRP. In addition, the students' academic origin, as well as the academic status and experience of advisors have a positive effect on the DRP; however, the total number of doctoral graduates associated with one advisor is negative to DRP. We find that the advisor factors play a key role in DRP; therefore, the government and universities should pay attention to improve faculty quality.

This study has contributed to a better understanding of the influential factors of DRP in the Chinese context. The results of our research are relevant not only for Chinese universities and advisors, but also for non-Chinese universities and advisors that are considering establishing a joint program with universities from China, where some of their students will be local. Furthermore, the model can be tested in other cultural contexts as to whether the chosen factors have significant influence on the DRP in other universities. We believe that readers from both the university advisors' and administrators' perspective will be interested in this study, given the increased attention of the field towards study of research performance in China.

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