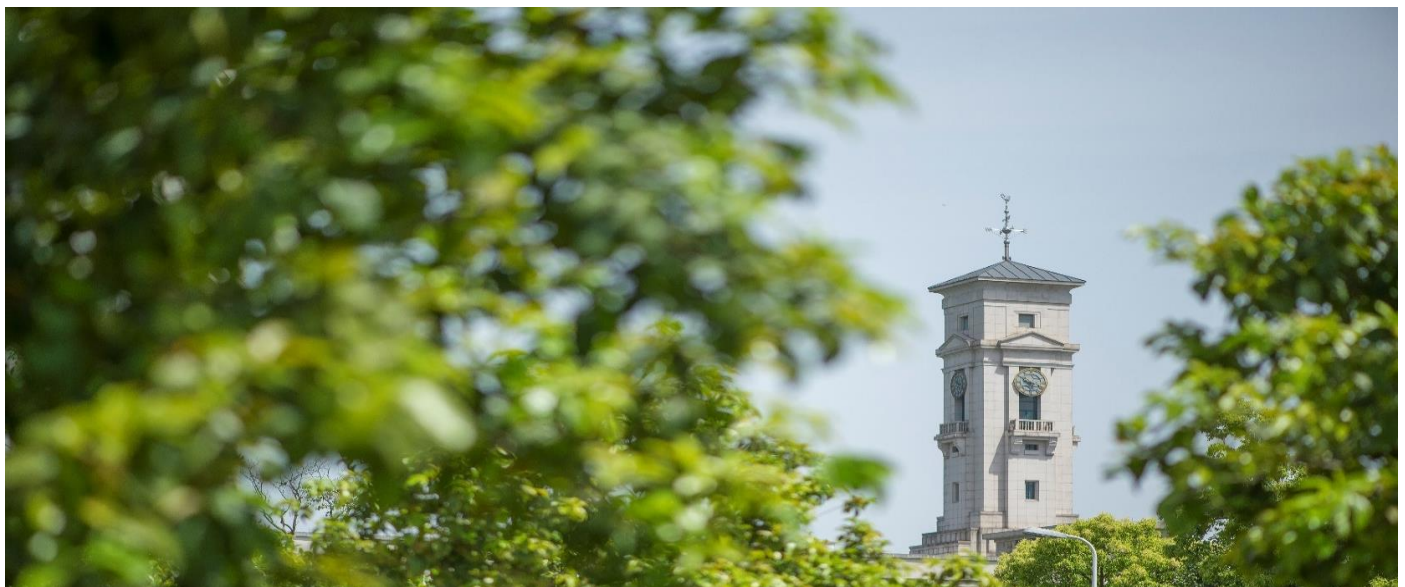


# Retraction: The “Other Face” of Research Collaboration?

Li Tang, Guangyuan Hu, Yang Suic, Yuhan Yang ,  
Cong Cao



**University of  
Nottingham**  
UK | CHINA | MALAYSIA

Faculty of Business, University of Nottingham Ningbo China, 199 Taikang East Road, Ningbo, 315100, Zhejiang, China.

First published 2020

This work is made available under the terms of the Creative Commons Attribution 4.0 International License:

<http://creativecommons.org/licenses/by/4.0>

The work is licenced to the University of Nottingham Ningbo China under the Global University Publication Licence:

<https://www.nottingham.edu.cn/en/library/documents/research-support/global-university-publications-licence-2.0.pdf>



**University of  
Nottingham**

UK | CHINA | MALAYSIA

## **Retraction: The “Other Face” of Research Collaboration?**

Li Tang<sup>a</sup>, Guangyuan Hu<sup>b</sup>, Yang Sui<sup>c</sup>, Yuhan Yang<sup>d,b</sup>, Cong Cao<sup>e</sup>

<sup>a</sup> Corresponding author, School of International Relations and Public Affairs, Fudan University, Shanghai, China, 200433, email: [litang@fudan.edu.cn](mailto:litang@fudan.edu.cn)

<sup>b</sup> Shanghai University of Finance Economics, Shanghai, China, 200433, email: [hu.guangyuan@shufe.edu.cn](mailto:hu.guangyuan@shufe.edu.cn)

<sup>c</sup> Kearney A.T., Shanghai, China, 200433, email: [suiyanghi@126.com](mailto:suiyanghi@126.com)

<sup>d</sup> College of Finance, Chongqing Technology and Business University, email: yangyuhan1229@163.com

<sup>e</sup> Co-corresponding author, Faculty of Business, University of Nottingham Ningbo China, 315100, email: [cong.cao@nottingham.edu.cn](mailto:cong.cao@nottingham.edu.cn)

**Acknowledgment:** We would like to thank anonymous reviewers for their comments. We particularly thank Dr. Stephanie J. Bird and Dr. Yvette Pearson for their insightful inputs and careful editing. This research draws on support from the National Natural Science Foundation of China (#71843009; #71774091; #71303147) and the Ministry of Education of China (#20172452). The conclusions contained herein are those of the authors and do not reflect the views of funders.

### **Author Contributions**

Research was designed by Li Tang and Guangyuan Hu. Original data downloading, coding and verification were executed by Yang Sui, Yuhan Yang, and Li Tang. Analyses were conducted by Guangyuan Hu, Li Tang, and Cong Cao. Writing was completed by Li Tang, Guangyuan Hu and Cong Cao.

---

## **Retraction: The “Other Face” of Research Collaboration?**

Li Tang, Guangyuan Hu, Yang Sui, Yuhang Yang, Cong Cao

**Abstract:** The last two decades have witnessed the rising prevalence of both co-publishing and retraction. Focusing on research collaboration, this paper utilizes a unique dataset to investigate factors contributing to retraction probability and elapsed time between publication and retraction. Data analysis reveals that the majority of retracted papers are multi-authored and that repeat offenders are collaboration prone. Yet, all things being equal, collaboration, in and of itself, does not increase the likelihood of producing flawed or fraudulent research, at least in the form of retraction. That holds for all retractions and also retractions due to falsification, fabrication, and plagiarism (FFP). The research also finds that publications with authors from elite universities are less likely to be retracted, which is particularly true for retractions due to FFP. China stands out with the fastest retracting speed compared to other countries. Possible explanations, limitations, and policy implications are also discussed.

**Keywords:** research collaboration; retraction; diffusion of responsibility; scientific misconduct

---

## **Introduction**

Team-dominated knowledge production has become ubiquitous globally. The trend of escalating co-publishing is evidenced by growing team sizes and by the proportions of multi-authored publications, many of which cross national borders (Cronin 2001; LaFollette 1992; National Academies 2014; Newman 2001; Wilson and Al 2011; Wuchty et al. 2007). Reasons for producing joint research vary, from greater epistemic authority (Beaver and Rosen 1979), resource optimization and cost sharing (Luukkonen et al. 1992), and more secured funding (Melin and Persson 1996) to higher-quality work (Cronin et al. 2004; Youtie et al. 2013). Meanwhile, the number and the annual rate of retracted scientific papers also have surged over the latest decades (Riederer 2014; Sheth and Thaker 2014; Steen 2011a; Zhang and Grieneisen 2012). The seeming coincidence, or at least concurrence, of rising rates of collaboration and retraction raises the following questions: Is there a relation between retractions and teamwork? If so, in which direction when other confounding factors are controlled? And what are the factors contributing to the elapsed time between publication and retraction?

Extant studies have explored retraction and scientific misconduct from different perspectives. Yet, to the best of our knowledge, no research has systematically investigated the relationship between retraction and collaboration. This study aims to fill this gap in the literature by examining the role of collaboration—both type and size—on retraction and elapsed time between publication and retraction. This research contributes to the literature on research misconduct in three ways. First, it examines the role of collaboration in spotting flawed or fraudulent research. Second, it provides a bibliometric analysis on retracted articles indexed in the Web of Science, focusing on both reasons for retraction and recidivism. Third, elapsed time to retraction was analyzed by differentiating reasons for retraction.

## **Literature review**

Revisiting the literature of research retraction

In the knowledge economy, both public policies and individual decisions, ranging from health to education, from parenting to business choices, are increasingly dependent on findings from scientific research, thus rendering scientific rigor and research integrity more important than ever (Macfarlane et al. 2014). Policymakers and research administrators have come to realize that fraudulent findings not only waste limited

---

public resources<sup>1</sup>, inhibit the ability of health care professionals to serve their patients well, but also tarnish the trust of the public toward science and scientists (Azoulay et al. 2012; Lacetera and Zirulia 2011; Stern et al. 2014; Zuckerman 1988). Unsurprisingly, over the latest decade, a growing number of studies have investigated the rising phenomenon of retraction, giving rise to four major research streams.

The first line of research describes this rising phenomenon. Studies consistently show that both the number and the growth rate of retracted articles have increased sharply (Fanelli et al. 2015; Fang et al. 2012; Nath et al. 2006). This high incidence of retractions not only occurs in biomedical articles indexed in PubMed but also spans other disciplines (Fanelli 2013; Zhang and Grieneisen 2013). In their efforts to understand the rising prevalence of retractions, Grant Steen and colleagues (2013) pointed out that the lower barriers to publications and retractions contribute to the sharp increase of retractions, and Daniele Fanelli (2013) noted that the greater institutional scrutiny facilitated by the rapid development of information and communications technology and scholarly communication plays important roles in identifying fraudulent research or false science. In this sense, the increasing number of retractions is a good sign of science's self-correction and oversight mechanism (Brainard 2018). Extant studies also found that retraction is particularly prevalent for research produced in countries such as the USA, Germany, Japan, China, the UK, and India.<sup>2</sup> China leads in duplicate publications, followed by the USA and India (Grieneise and Zhang 2012). Daniele Fanelli and colleagues (2015) maintained that scientific misconduct is more likely to occur in countries that highly incentivize publications while lacking clearly defined and operational research integrity policies. Shunhai Qu and Viroj Wiwanitkit (2015) argued that such country differences lie in the size of the researcher pool and the research output volume as well as the perception of misconduct.

The second line of research into retraction categorizes the reasons behind it. Sara Nath and colleagues (2006) found that more than two-thirds of the biomedical retractions between 1982 and 2002 resulted from unintentional mistakes such as inappropriate sampling procedures, coding mistakes and the others. Steen (2011b) also reported that about three-quarters of the retracted PubMed papers between 2000 and 2010 are due to errors or undisclosed reasons. Different findings also emerge. By combining information from Retraction Watch, the U.S. Office of Research Integrity (ORI), and other public sources, Ferric Fang and colleagues (2012) reported that only one-fifth of the retractions resulted from errors, whereas over two-thirds of the papers were removed

---

<sup>1</sup> For example, Andrew Stern and colleagues (2014) noted that on average, each retracted article funded by the U.S. National Institutes of Health between 1992 and 2012 incurred an average direct cost of about 392 thousand US dollars.

<sup>2</sup> The ranking order of these countries changes a bit due to different coverage of retraction articles.

---

because of scientific misconduct manifest in falsification, fabrication, and plagiarism (FFP).<sup>3</sup>

The third strand of investigation focuses on factors influencing the likelihood of retraction, and elapsed time between publication and retraction. Research has consistently reported that the number of retractions is correlated significantly with the impact factors of the journals in which the retracted papers were published. Nikolaos Trikalinos and colleagues (2008) observed that retractions resulting from falsification often take longer, especially when senior researchers are involved. Steen (2011b) also argued that a journal's impact factor is often significantly higher for fraudulently produced papers, as their authors might target journals with a high impact factor. The same findings were reported by Ryoji Noyori and Joe Richmond (2013): the higher the journal's impact factor, the more retractions there were. They speculated further that the incentives of publishing in high-impact journals, such as career development and receipt of research grants, played an important role in stimulating fraudulent authors.

Recently, studies have also appeared treating the event of retraction as an independent variable and examining its impact on individual development. For example, Laura Bonetta (2006) reported the negative influence of research misconduct on coauthors' reputations and career development. Ginger Jin and colleagues (2013) documented a heterogeneous impact of retraction penalties on eminent and less-famous collaborators. The reverse Matthew Effect was observed with less citation penalty on more established researchers.<sup>4</sup> In a similar vein Philippe Mongeon and Vincent Larivière (2016) noted that retraction does negatively impact authors' career development but with primary authors, namely first authors and reprint authors, suffering more. Along this line of investigation, some studies examined the impact of retraction on the advancement of research fronts. Pierre Azoulay and colleagues (2012) investigated the extent to which retraction event impacts the rate and the direction of science development. Their research revealed that both funding and knowledge production activities decreased in the areas of false science. This negative spillover effect of retraction is also supported by Susan Feng Lu and colleagues (2013). They found that the citation penalty for non-self-reporting retraction goes

---

<sup>3</sup> Different samples and coding schemes are the two main reasons accounting for the different results between Steen (2011b) and Fang and colleagues (2012). First, while both used PubMed as the data source, Steen (2011b) covered about 800 retracted articles between 2000 and 2010, while Fang and colleagues (2012) looked at some 2,000 retracted articles between 1973 and May 2012. Second, Steen (2011b) collapsed "undisclosed reasons" for retraction under the category of errors based on retraction notices, while Fang et al. (2012) improved the research by incorporating information from ORI. It is interesting to note that Steen also is a coauthor of the Fang and colleagues (2012) paper.

<sup>4</sup> According to Robert Merton (1968), the Matthew Effect refers to the cumulative advantages of renowned scientists who tend to garner more credit than those unknown with equal contributions. In the research of Jin and her colleagues (2013), the term "reverse Matthew Effect" means eminent scholars still win with less credits taken away compared to the less eminent ones who were also punished for retracted articles.

---

beyond the retracted paper itself.

In spite of the growing number of studies on retraction, one research gap is a possible connection between co-publishing and retraction. In a departure from past scholarship, this paper studies the connection between co-publishing and retractions and tries to further understand the factors affecting/influencing the likelihood of retraction and the time it takes for the false science to be removed from the literature. Of particular interest is whether there is a relationship between collaboration and the likelihood of retraction as well as the speed of retraction.

### Hypotheses for testing

As an old proverb goes, too many cooks spoil the broth. In the social psychology literature, diffusion of responsibility, also referred to as *bystander effect*, suggests that an individual is less likely to take responsibility for action or more likely to be idle in the presence of others, as the individual assumes that others either are responsible for taking action or have already done so (Darley and Latane 1968). This bystander inaction can occur in real-life academia. In the case of joint publication, for example, it is reasonable to assume that each coauthor behaves as though the responsibility for the credibility and quality of the coauthored work is diffused and thus does not necessarily take care of the validity of the collective knowledge product. This underperformance due to diffusion of responsibility, combined with the costs of collaboration such as knowledge fragmentation and coordination failure (Youtie and Bozeman 2014), increases the likelihood of producing flawed scientific findings, which, in return, leads to a higher probability of retraction. The first hypothesis is

*H1: Research collaboration increases the probability of retraction holding other factors constant.*

Retraction is a self-correction mechanism of the science community. When a paper is retracted, its findings are invalidated. The sooner a flawed or fraudulent paper is retracted, regardless of the reason, the less of a negative impact it will have on future research (Fanelli 2013; Gasparyan et al. 2014). However, existing research has paid very little attention to the factors affecting the time between publication and retraction, with few notable exceptions. Trikalinos and colleagues (2008), for example, reported an average two-year retraction time. Jeffrey Furman and colleagues (2012) argued that no observable factors affected the time to retraction except for publication year, whose statistically significant and negative regression coefficient provided strong evidence in support of the trend of shortened times of detecting flawed findings.

Joint research on average receives more citations and scholarly attention (Glänzel and Schubert 2004; Van Raan 1998) and thus greater scrutiny and a higher possibility of being detected more quickly for its shaky or fraudulently produced findings (Furman et al. 2012). Thus the second hypothesis is



---

*H2: Research collaboration decreases the elapsed time between publication and retraction.*

The status of authors or their affiliated institutions also can influence the likelihood of retraction (Furman et al. 2012). Prominent scientists are less likely to be caught for misconduct than average scientists (Lacetera and Zirulia 2011). One explanation is scholars from elite universities are care more about their academic reputations and those of their home institutions. The anticipated cost of attempting fraud is considerable for prominent scholars who have established their professional reputations (Fanelli et al. 2015; Lacetera and Zirulia 2011). From the perspective of organizational studies, John Walsh and his colleagues (2019) argued that university norms, culture and other unobservable features can also influence researchers' attitude and behaviors. Additionally, it takes courage to challenge the findings or even the integrity of researchers from elite universities who enjoy more epistemic authority and often evaluate and make decisions on other researchers' funding applications and promotions (Hao 2009). Thus, the third hypothesis is

*H3: Research collaboration involving researchers from elite universities is less likely to be retracted.*

In the same vein, an author's or institution's status in the academic hierarchy also influences the time to retraction. For example, Trikalinos and his colleagues (2008) found that fraudulent or flawed articles by senior researchers take a longer time to be retracted.<sup>5</sup> Nicola Lacetera and Lorenzo Zirulia (2011) posited that questioning the work of established scholars could be costly for junior researchers in terms of their future publishing opportunities and career advancement. This leads to the fourth hypothesis:

*H4: It takes longer for a flawed paper involving collaboration with scholars from elite universities to be retracted.*

## **Data and Method**

A unique dataset was constructed to address the research questions and test these hypotheses. The primary source is a set of retracted papers retrieved from the core sets of Web of Science (WoS),<sup>6</sup> which indexes about 11,600 peer-reviewed journals spanning a wide spectrum of disciplines. A composite Boolean query was used to

---

<sup>5</sup> It needs to point out that there is no agreed upon definition on elite scholars, star scientists, senior scholars, or established researchers in extant literature. These terms are often used interchangeably. According to Trikalinos et al (2008) senior scholars refer to professors, lab directors, experienced investigators or researchers who had more than five- year record of publishing original articles. In this research, a dummy variable of Top 100 universities is used as a proxy indicator of an institution's research status (also see Walsh et al. 2019). For more details please refer to the section of variables..

<sup>6</sup> The core datasets of WoS consist of Science Citation Index, Social Science Citation Index, and Arts & Humanities Citation Index. The data were accessed and downloaded from the library at the Shanghai University of Finance and Economics.

---

search for retraction notices in January 2014 using “retract\*” in the fields of title, key words, and abstract. The search was confined to the document type of corrections for the period from 1978 to 2013. This returned 2,648 retrieved hits. The full texts of retraction notices were downloaded with each linking to a corresponding retracted article. Two independent teams manually read all retraction notices. After several rounds of independent verification, cross-checking, and removing duplicates and irrelevant records, eventually 2,087 unique retracted papers published between 1978 and 2013 were identified.<sup>7</sup>

The full bibliographical records of the retracted articles indexed in WoS were downloaded. Based on the nearest-neighbor-matching principle proposed by Jeffrey Furman and colleagues (2012), each retracted paper was initially matched with two control articles immediately before and after the retracted one in the same issue of the same journal. If neither qualifies (for example, its document type is conference abstract, letter, correction, or editorial, among others), the retracted paper was then matched with its next nearest neighbor. The farthest neighborhood distance is three, i.e., three papers ahead of or behind the retracted one. If a retracted article was the first or last one in an issue, only one matched article will be identified. In this way, and with several rounds of data cleaning and standardization, 3970 control records were finally identified with a 96.6% matching rate. The two datasets were then imported into the text mining software VantagePoint. The final core dataset for analysis consists of 6,057 records with 2,087 retracted articles and 3,970 associated control matched articles. Journal impact factors and global rankings of the institutional affiliations of the authors of the retracted and control articles were retrieved from the 2012 ISI Journal Citation Reports (JCR)<sup>8</sup> and the 2014 Academic Ranking of World Universities (ARWU) respectively and integrated into the publication dataset.<sup>9</sup>

---

<sup>7</sup> This figure is consistent with Fanelli’s (2013) 2,294 retractions published from 1901 to 2012. Only retracted original research articles were included for further analysis.

<sup>8</sup> For robustness check, each record was also matched with the journal impact factor (hereinafter JIF) of its publishing year or the nearest available year. For example, for a retracted paper published in 1980, we matched it with 1997’s journal impact factor when the earliest JCR report was released. The correlation between these two columns of journal impact factors are as high as 0.99. So the 2012 journal impact factor was chosen for the rest of the analyses. Within the authors’ best knowledge, all previous studies on retractions and journal impact factors used the last available journal impact factor without examining the possible fluctuations of journal impact factor over a long period, or at least this issue was not mentioned in the extant studies (e.g., Steen 2011 and Furman et al. 2012). We would like to thank an anonymous reviewer for his or her insight to direct us toward this examination.

<sup>9</sup> For consistency, non-university institutions such as the Chinese Academy of Sciences and U.S. national laboratories were treated as non-elite.

---

## Analyses

### Retraction reasons

Retraction occurs for a variety of reasons, ranging from fabrication, falsification, and plagiarism (FFP) to duplicate publication, lack of Institutional Review Board (IRB) approval, scientific errors, author disputes, and the like (Fanelli et al. 2015; Fang et al. 2012; Furman et al. 2012; Steen et al. 2013; Wager and Williams 2011; Williams and Wager 2013). Independent coding of the reasons for retractions in the dataset was carried out from June to July in 2017 by two research teams based on agreed-upon procedures. Inter-coder reliability had an agreement rate of 92% on the first round. For those 177 cases where there was disagreement in the first round, a third person discussed each case with the coders to reach consensus in the end. Any discrepancy was checked by the third researcher. The coding scheme of 13 types of retractions, the number of cases, and illustrating examples are detailed in Appendix 1.

Following former practices (Furman et al. 2012; Gasparyan et al. 2014), we further aggregate reasons for retraction into four categories: misconduct and suspected misconduct (types 1 through 10), scientific errors (type 11), publisher errors (type 12), and unknown (type 13). Figure 1 depicts the distribution and dynamics of retraction reasons. Approximately three-quarters of the retracted papers are attributable to different types of scientific misconduct, including suspected misconduct, among which FFP take a half share and about another quarter (23%) is attributable to suspected fraud. Authors' significant errors accounted for 14% of the total retractions. It also is interesting to point out that 129 papers were retracted for multiple reasons. Retractions for all reasons have grown over time, but FFP consistently are the leading reasons of retraction. These findings are consistent with previous studies (Mongeon and Larivière 2016; Steen et al. 2013).

[Figure 1 Inserted here]

Table 1 lists the top ten “repeat offenders” who have retracted at least 20 articles in our dataset. Together they comprised 226 unique retracted articles, roughly 11% of our sample. Nine of the ten repeat offenders are from the top five countries with the largest amount of retracted papers: 5 from Japan, 2 from Germany, and 2 from the U.S.. Seven are in the research domain of the life sciences, two are in physics, and one is in psychology. The top ten recidivists are all male. This finding echoes that of Ferric Fang and colleagues (2013) that males are overrepresented in misconduct in the life sciences. Ten repeat retractors are all collaboration prone. Three clusters of retracted papers are highlighted by different colors in Table 1. The tight interconnection among repeat retractors itself is worthy of further investigation. Some are leading offenders (such as Yoshitaka Fujii and Jan Hendrik Schön) verified by respective investigation committees, while some

---

are only followers (such as Christian Kloc) or even innocent collaborators as Mongeon and Larivière (2016) suggested.<sup>10</sup>

[Table 1 inserted here]

## Bibliometric analysis

### *Temporal and geographical distribution*

The data indicate that between 1978 and 2013, both the number and growth rate of retractions increased over time. This is consistent with the findings of previous studies despite different examination periods and publication coverage. As illustrated in Figure 2, the rapid growth of retracted papers is mainly driven by misconduct. Compared to the steady growth of retractions for errors, retracted articles resulting from misconduct have been growing at a significant rate.

[Figure 2 Inserted here]

The data also reveal that the distribution of retracted research is highly skewed nationally. The top five countries in terms of the number of retracted articles are the USA (622), China (341), Japan (263), Germany (184), and India (141). This is consistent with previous studies (He 2013; Lanzafame 2013; Steen 2011a; Oransky 2018), though the ranking order of the top five countries changed a bit given the different coverage of retraction articles analyzed. Extant studies suggest that nation size and the pool of researchers account for the considerable variability of retractions at the country level (Amos 2014; Fang et al. 2012; Noyori and Richmond 2013). Countries' global shares of retracted papers and all publications are compared in Figure 3. As shown, the USA published and retracted similar global percentages of papers (30.7% vs. 29.8%). With each producing some 7% of the total WoS papers during the period of study, China and Japan retracted much higher percentages of papers than Germany. India's share of the retracted papers was 2.5 times its share of the total WoS papers.<sup>11</sup>

[Figure 3 Inserted here]

Based on the implication in Figure 3 that countries publishing a smaller number of papers may have a larger percentage of retractions, further analysis of all countries which have been involved in at least ten retractions in this dataset revealed that, surprisingly, Egypt turns out to be the country with the largest share of

---

<sup>10</sup> One retraction notice involving Schön, Kloc, and Batlogg explicitly stated “The committee found one researcher had committed scientific misconduct and cleared the other authors investigated.” The same committee stated in the investigation report on another retracted paper that “based on the preponderance of the evidence, Hendrik Schön committed scientific misconduct as defined by the falsification or fabrication of data, such that the research is not accurately represented in the research record.”

<sup>11</sup> When only primary authors (i.e., first authors and corresponding authors) are considered, the top five countries with the largest numbers of retracted papers are USA (528), China (310), Japan (243), Germany (145), and India (139). Removing repeat offenders from the sample, the top five countries remain the same, but now Japan and Germany rank after India: i.e., USA (494), China (310), India (139), Japan (127), and Germany (106).

---

retractions: for every ten thousand (10,000) Egyptian publications, about 3.04 papers were retracted over the examined period. It is followed by Iran (2.95‰), South Korea (2.19‰), China (2.16‰), and India (1.93‰) in descending order. The full list is shown in Appendix 2.

#### *Journal impact factors*

The subject-specific quartile impact factors of each journal were calculated based on the 2012 ISI JCR. If a journal is assigned to different subject categories or disciplines<sup>12</sup>, its impact factors at both the highest and lowest quartiles were calculated. Consistent with previous findings noted above, our analysis indicates that retractions appeared more frequently in journals with higher impact factors. This conclusion holds taking into multidisciplinary journals with different subject-specific JIF. As illustrated in Figure 4, when taking the lowest quartiles for all journals, 46% of the retracted articles were published in Quartile-1 journals (high-impact-factor journals) while only 11% were in Quartile-4 journals (low-impact-factor journals). Using journals' highest impact-factor quartiles, the retractions were 55% in Quartile-1 but 7% in Quartile-4.

[Figure 4 Inserted here]

#### *Disciplinary distribution*

With regard to research domains, similar to the findings of Susan Feng Lu and colleagues (2013) and Fanelli (2013), which also analyzed WoS retracted articles, our data show that retraction was more common in the biomedical and life sciences. As illustrated in the inner circle of Figure 5, over 60% of the retracted articles were in the life sciences and biomedicine; by sharp contrast, only 0.1% of arts and humanities papers and 5.1% of social sciences papers were retracted. The highly uneven distribution of retractions across disciplines may reflect the possible lower incidence of false science, or lower rates of detection of problematic research in the arts and humanities and social sciences, where replicability is harder to implement (Fox and Braxton 1994). The outer circle of Figure 5 illustrates the distribution of retracted articles against all publications in the five research areas between 1990 and 2013.

Apparently, the proportion of retracted life sciences and biomedicine articles is one-third more than their share of WoS articles, which only contributed 42.5% of the indexed publications.<sup>13</sup> The leading scientific nations such as the USA, China, Japan, Germany, and India all witnessed higher proportions of retractions in life sciences and biomedicine relative to their shares of papers in this research domain. The enormous

---

<sup>12</sup> For example, *Acta Neurochirurgica* (ISSN: 0001-6268) had an impact factor of 1.546 in 2012, which ranked the 126th among 193 journals in the field of clinical neurology, i.e., the third quartile, and 85th of 199 in surgery, i.e., the second quartile.

<sup>13</sup> Only four document types—article, review, note, and letter—are retrieved and used in our investigations.

---

consequences and economic potential of the research in these fields as well as the fierce competition for positions, promotions, funding, and especially priority of discovery and peer recognition might have led life scientists to rush to publish. On the other hand, once published such publications are more likely to be subject to stricter peer scrutiny for the same reasons. Such attention, facilitated by an expanded scientific community and information communications technologies, may mean that internal errors are more likely to be caught (Fanelli 2013; Steen et al. 2013).

[Figure 5 Inserted here]

#### *Collaboration and retraction*

Of the 2,087 retracted papers, 93% had two or more authors, with 51% involving inter-institutional collaboration and 19% collaboration across national borders. Table 2 compares the collaboration size (number of authors, number of affiliations, and number of countries) and the time to retraction for retracted papers vs. control groups. As shown, retracted articles, in general, have smaller collaboration dimensions of author, affiliation, and country. Next the paper examined whether such difference is statistically significant controlling for other factors.

[Table 2 inserted here]

#### Statistical analysis

##### *Variables*

Dependent variable. The unit of analysis is the article. The two key focal variables of the study are 1) retraction of flawed research and 2) retraction time lag. The first dependent variable, retraction, is a dichotomous variable: an article is coded 1 if it is in the retraction group and 0 if in the control group. The second dependent variable is time to retraction, a continuous variable measured by the natural log of the elapsed months between an article's publication and its retraction.<sup>14</sup>

Explanatory and control variables. The major independent variable of the study is research collaboration. It is measured by the following three indicators:

- Number of authors: numerical variable, number of authors
- Number of affiliations: numerical variable, number of unique affiliations
- Number of countries: numerical variable, number of unique countries

---

<sup>14</sup> There are 108 retracted articles with missing values of the publication month for either the retracted article or the retracted notice. Their elapsed months were estimated by assuming the same month of publication and retraction.

---

The institutional factor was measured by a dummy variable indicating whether any author is affiliated with elite universities, i.e. the Top 100 universities reported by the 2014 Academic Ranking of World Universities (ARWU).<sup>15</sup> Additionally, year of publication, research domain, and journal's impact factor, a set of primary country dummy variables was included in the regression models to control for the research culture factor.

### *Regression Results*

The logistic regressions were adopted to test Hypotheses 1 and 3 while using the natural logarithm of the time to retraction in months to test Hypotheses 2 and 4. The primary results are presented in Tables 3 and 4 (in both tables, Panels 1 and 3 are for the global dataset while Panels 2 and 4 focus on the FFP sub-dataset).<sup>16</sup>

[Tables 3 & 4 Inserted here]

Several findings are noteworthy. First, the evidence does not support hypothesis 1 that research collaboration increases the chance of producing false science. The odds ratios of collaboration size are less than 1 and statistically significant for the number of authors, indicating that collaboration size is negatively associated with the retraction event holding other factors constant. In other words, all else being equal, an increase in the number of collaborators does not increase the likelihood of retraction. This holds for all types of retractions and also for retractions due to FFP as well. One possible explanation is that cross-pollination of different minds and validation of findings ensure a higher standard of quality control and thus a more robust research that is less likely to be retracted. In other words, a larger collaboration size hints more internal auditing among research collaborators, and therefore a higher chance of identifying fraud or significant errors prior to publication with scrupulous checking and knowledge validation. Meanwhile it takes longer to retract a flawed paper involving more authors. As also shown in Table 4, collaboration sizes are all positively correlated with retraction time. One speculation is that it may take longer and involve more effort for a journal to investigate a multi-authored paper to make the final decision of retraction; but such an impact is only statistically significant for the number of authors. Hypothesis 2 is partially supported.

---

<sup>15</sup> Considering the possible stability of ARWU ranking, the rankings of 2014's Top 100 universities in the year of 2003, the earliest year of ARWU rankings, were also downloaded. The comparison reveals that eighty-two of the Top 100 universities listed in 2014 were also in the Top 100 ranking of the year of 2003.

<sup>16</sup> Taking the possible nonlinear effect of collaboration into consideration, we also added squared terms of all three indicators in the regressions. Other robustness tests we conducted include changing any author affiliated with a Top-100 university to a primary author (i.e., first author and reprint author), changing the numerical measurement of collaboration to a set of three dummy variables, excluding retractions due to publisher errors and unknown reasons and their matched records in the regression, and excluding articles coauthored by repeat offenders. Overall, the results remain robust and support the main finding.

---

Second, the data suggest that publications with authors from elite universities were less likely to be retracted. Globally, only slightly over one in five (22.6% to be exact) retracted articles involved at least one author from a Top-100 university, and 14.9% of the retracted articles had a first or reprint author from an elite university. As shown in Table 3, the odds-ratio for authors affiliated with a Top-100 university to withdraw a paper is 0.77. That means that, holding other factors constant, the odds of an article with at least one author from a Top-100 university being retracted were 23% lower compared with one without such an author, thus suggesting a stronger tendency among global elite universities to inhibit retractions. This is particularly true for retraction due to FFP. The same pattern also holds when the collaboration size is measured by the number of institutions and the number of countries involved in collaboration. This empirical finding is consistent with the Game-Theory related finding that elite authors are less likely to be caught in misconduct even if the probability of publishing a fraudulent paper is higher (Lacetera and Zirulia 2011). It may also suggest that collaborating with prominent scholars has a smaller chance of producing floppy work leading to retraction. Meanwhile, as indicated by the negative signs of regression coefficients in Table 4, if a paper coauthored by an elite scientist had to be retracted, it was retracted more quickly.<sup>17</sup> One possible reason for this phenomenon is that collaboration involving leading scientists is likely to produce findings at the frontier, which are likely to be scrutinized and replicated by a greater number of follow-ups. Therefore, flaw or fraudulence, if any, is detected more quickly by the larger scientific community. Moreover, elite scientists may take more proactive steps and retract papers immediately once the research is suspected of falsification.

The third and final notable finding concerns collaboration involving scientists from the countries with the largest numbers of retractions. As demonstrated in Panel 1 of Table 3, among the top five countries with the largest number of retractions, *ceteris paribus*, China and India stand out with the largest likelihoods of retraction of research involving their scientists as primary contributors.<sup>18</sup> This finding echoes Adam Segal's (2011) statement that the emerging scientific powers whose goals of intimately linking scientific research to the

---

<sup>17</sup> This finding is different from that of Furman and colleagues (2012) in that retraction is uncorrelated with article, author, or institution characteristics. Different data coverage and elite university measurement could lead to this discrepancy. While Furman and colleagues (2012) focused on medical sciences using data from PubMed between 1977 and 2006, our analysis covered broader fields with data retrieved from WoS for a longer period of time, between 1978 and 2013, thus extending the study of the retraction phenomenon to a much larger retracted group (2,087 vs. 677). Furman and colleagues (2012) controlled for the Top 25 U.S. universities, while we examined the global retraction phenomenon by controlling for the involvement of authors from global Top-100 universities and explicitly measured collaboration through three indicators: number of authors, number of affiliations, and number of countries.

<sup>18</sup> Considering retractions due to FFP, articles with primary authors from Japan also have a larger likelihood of being retracted, as indicated in Panel 2. This may be due to the influence of Japanese repeat offenders as demonstrated in Table 1.



---

national pride of catching up with and surpassing the incumbents sometimes have ended up with unintended and mostly undesirable consequences. Panels 3 and 4 of Table 4 show that among the five countries, only articles with primary authors from China demonstrate negative associations with time to retraction. In other words, China is the country whose scientists retracted papers most quickly.

## **Discussion and Conclusions**

This paper investigated the characteristics of retracted papers indexed in the Web of Science. Inspired by prior scholarship (for example, Azoulay et al. 2012; Furman et al. 2012; Jin et al. 2013; Lu et al. 2012), our research brought a new perspective—collaboration—into the literature on research retraction and provided empirical evidence on the driving factors and the speed of retraction. We found that research misconduct is the main driver of retractions. The majority of retracted papers are multi-authored. Repeat offenders, including both leading recidivists and followers, are collaboration prone.

Yet, when controlling for compounding factors such as research domain, publication year, journal visibility, research environment and culture, our findings provide suggestive evidence that working together helps encourage responsible behavior among researchers; i.e. retraction may be not the other face of research collaboration. On average, collaborated research is less likely to be “false science”. And that such “false science,” once involved with researchers from elite universities, is retracted more quickly. Of course, the size and types of collaboration themselves could be endogenous and driven by the factors mentioned above as well as other factors such as easy access to facilities and resources, validation of knowledge, the inherently interdisciplinary and exceptionally exploratory nature of the research at the frontier, or increased efficiency of knowledge production due to division of labor (Beaver and Rosen 1979; Uzzi and Spiro 2005).

Our research has some limitations. To begin with, given that this empirical study is based upon secondary data, we can speculate only within our knowledge of research governance practice and extant literature. Second, we confine our search to WoS core datasets over the period of 1978–2013, so retractions after 2014, or not indexed in WoS, are not included in our sample. The four-wave large-scale retractions of Chinese articles from publishers BioMed Central, Springer, and Elsevier since 2015, including the 107 Chinese retracted articles in 2017, were outside our examination scope (Hu et al. 2019; Lei and Zhang 2017). Third and also related, retraction is only the tip of the iceberg of scientific misconduct, which may arise from a full spectrum of knowledge generation and diffusion. Due to the nature of our research, it is impossible to come up with a more comprehensive picture of misconduct, so we would like to remind readers not to overextend our conclusions.

---

Finally, the caveats of statistical tests and misinterpretation of results have been discussed in previous studies (for more discussion please see Schneider 2011, 2015). We need to be cautious and should not over-interpret the results based on statistical results alone.

Bearing those limitations in mind, we also draw from our findings some policy implications for research collaboration and evaluation practices. First, scientific misconduct is a growing problem that has bedeviled the research community in recent decades. Globally, there is a compelling government interest in promoting responsible research behavior and invalidate “false science” as soon as possible. Our study suggests that jointly published research with contributions of primary authors from top universities is less likely to be retracted; but once retracted the elapsed time between publication and retraction is rather short. This finding offers empirical support for policy proposals that endorse research collaboration, especially that involving scientists at top universities.

Second, our findings are relevant to current performance evaluation policies in some countries that highly de-incentivize collaboration (Yan et al. 2016; Zhou et al. 2009). China is now among the world’s largest scientific knowledge producer (Tang 2019). Yet, in many Chinese universities only the status of the first author or reprint author is counted toward faculty tenure and promotion (Wang et al. 2015). For example, the written criteria for tenure and promotion at some institutions, such as Shanghai Jiao Tong University, clearly state that to be eligible for promotion to a higher academic rank a faculty member must publish two first- or reprint-authored papers in WoS-indexed journals. This means that any paper in which an academic is listed as a second or other author will be highly discounted if not completely excluded. Therefore, academics are understandably reluctant to collaborate if they are not listed as primary authors, especially with competitors within the same institution. This has suffocated internal collaboration (Wang et al. 2015).<sup>19</sup> If, however, Chinese universities change policies to give credit to all authorships toward tenure or to count all authorships reasonably, this would stimulate collaboration, although it also may invite free ridership. Therefore, some universities, such as the Shanghai University of Finance and Economics, have adopted sophisticated fractional counting formulas for credit sharing to reduce the existence of possible ghost authors. Of course, collaborators need to understand that the privilege of authorship comes with not only credit but also responsibility.

Third, our empirical analysis demonstrates that collaborative publications with Chinese or Indian

---

<sup>19</sup> The concern is comparatively less considering international collaboration, as Chinese researchers do not compete against international partners for promotion and research funding. Nonetheless, secondary authorship is highly undervalued for Chinese researchers in the situation of international collaboration.

---

scientists as primary authors are far more likely to be retracted than those led by scientists from other major scientific countries. This is consistent with the general concern about developing and emerging scientific countries such as China and India that still lack intellectual capital but strive to seek their seats at the league table of global academia (Cao et al. 2013; Liu et al. 2015; Wang et al. 2015). Therefore, the Chinese and Indian governments should have incentives to tackle the frequent and rising incidence of problematic research involving their scientists, as such research could damage the reputations of not only their scientists but also their countries (Kornfeld and Titus 2016). Scientists from these countries need to make extra effort to maintain the integrity of their work, because problematic research, if not stopped, will only discourage collaboration and delay the process through which these countries pursue scientific excellence.

Fourth, diffusion of responsibility is more likely to occur when a large number of scientists are involved with unclear defined task on each individual. Previous work has studied contribution statement and examined how division of labor influences the likelihood of producing flawed or fraudulent research (Walsh et al. 2019). Journals such as the *Proceedings of the National Academies of Sciences* and *Nature* require or at least encourage authors to clearly identify author contributions. To deter publishing retractions by instilling authorship responsibility and transparency, we appeal for all authors and journal articles to state explicitly which author has contributed what in collaborative research. CRediT (Contributor roles taxonomy) can be one good option (Brand et al. 2015; McNutt et al. 2018).

---

## References

- Amos, K.A. (2014). The ethics of scholarly publishing: Exploring differences in plagiarism and duplicate publication across nations. *Journal of the Medical Library Association*, 102(2), 87–91.
- Azoulay, P., Furman, J. L., Krieger, J. L., & Murray, F. (2012). Retractions. *NBER Working Paper*.
- Beaver, D. D., & Rosen, R. (1979). Studies in scientific collaboration. Part III. Professionalization and the natural history of modern scientific co-authorship. *Scientometrics*, 1(3), 231–245.
- Biochemical and biophysical research communications (2009), 388(2), 464-464. doi:10.1016/j.bbrc.2009.08.011
- Bonetta, L. (2006). The Aftermath of scientific fraud. *Cell*, 124(5), 873–875.
- Brainard, J. (2018). Rethinking retractions. *Science*, 362 (6413), 390-393, doi: 10.1126/science.362.6413.390
- Brand, A., Allen, L., Altman, M., Hlava, M., & Scott, J. (2015). Beyond authorship: attribution, contribution, collaboration, and credit. *Learned Publishing*, 28(2), 151-155.
- Cao, C., Li, N., Li, X., & Liu, L. (2013). Reforming China's S&T System. *Science*, 341, 460-462.
- Cronin, B. (2001). Hyperauthorship: A postmodern perversion or evidence of a structural shift in scholarly communication practices? *Journal of the American Society for Information Science and Technology*, 52(7), 558–569.
- Cronin, B., Shaw, D., & Barre, K. L. (2004). Visible, less visible, and invisible work: Patterns of collaboration in 20th century chemistry. *Journal of the American Society for Information Science and Technology*, 55(2), 160–168.
- Darley, J. M., & Latane, B. (1968). Bystander intervention in emergencies: Diffusion of responsibility. *Journal of Personality and Social Psychology*, 8(4), 377–383.
- Fanelli, D. (2013). Why Growing Retractions Are (Mostly) a Good Sign. *PLoS Medicine*, 10(12): e1001563.
- Fanelli, D., Costas, R. & Larivière, V. (2015). Misconduct policies, academic culture and career stage, not gender or pressures to publish, affect scientific Integrity. *Plos One*, 10(6), e0127556, doi: 0127510.0121371/journal.pone.0127556.
- Fang, F. C., Bennett, J. W. & Casadevall, A. (2013). Males are overrepresented among life science researchers committing scientific misconduct. *Mbio*, 4(1), 00640-00612.
- Fang, F. C., Steen, R.G., & Casadevall, A. (2012) Misconduct accounts for the majority of retracted scientific publications. *Proceedings of the National Academy of Sciences*, 109(42), 17028–17033.
- Fox, M. F., & Braxton, J. M. (1994). Misconduct and social control in science: Issues, problems, solutions. *The Journal of Higher Education*, 65(3), 373–383.
- Furman, J. L., Jensen, K., & Murray, F. (2012). Governing knowledge in the scientific community: Exploring the role of retractions in biomedicine. *Research Policy*, 41(2), 276–290.
- Gasparyan, A. Y., Ayvazyan, L., Akazhanov, N. A., & Kitas, G. D. (2014). Self-correction in biomedical publications and the scientific impact. *Croatian Medical Journal*, 55(1), 61–72.
- Glänzel, W. & Schubert, A. (2004). Analyzing scientific networks through co-authorship. Handbook of quantitative science and technology research. In Moed, H. F., Glänzel, W., & Schmoch, U. - I.(Ed.), *Handbook of Quantitative Science and Technology Research* (pp. 257–276). Netherlands: Kluwer Academic Publishers.
- Grieneisen, M. L., & Zhang, M. (2012). A comprehensive survey of retracted articles from the scholarly literature. *Plos One*, 7(10), e44118. doi: 10.1371/journal.pone.0044118

- 
- Hao, X. (2009). Scientific misconduct-Retractions Put Spotlight on China's Part-Time Professor System. *Science*, 323(5919), 1280-1281.
- He, T. (2013). Retraction of global scientific publications from 2001 to 2010. *Scientometrics*, 96(2), 555–561.
- Hu, G., Yang, Y. & Tang, L., Retraction and Research Integrity Education in China, *Science and Engineering Ethics*, 25(1), 325-326.
- Indian Journal of Surgery (2013), 75, 251-251.doi:10.1007/s12262-013-0925-1.
- Infection and immunity (2011). 79(1), 545-545. doi: 10.1128/IAI.01068-10
- International Journal of Biological Macromolecules (2013), 52, 20-20.
- Intensive Care Medicine (2011). 37, 1231-1231. doi:10.1007/s00134-011-2218-0.
- Jin, G., Jones, B., & Lu, S. F. (2013). The reverse Matthew Effect: Catastrophe and consequence in scientific teams. *NBER Working Paper*. <http://www.nber.org/papers/w19489>
- Journal of Applied Physics (2011), 109(10), 109903, doi: 10.1063/1.3583532
- Journal of Cutaneous Pathology (2010), 37(11), 1190-1190.
- Journal of Experimental & Clinical Cancer Research (2011). 30, 19-19. doi: 10.1186/1756-9966-30-19.
- Journal of Mathematical Analysis and Applications(2011). 380(1), 403-403. doi:10.1016/j.jmaa.2011.02.069.
- Journal of Mathematical Analysis and Applications (2013). 398(1), 456-456.
- Kornfeld, D. & Titus, S. L. (2016). Stop ignoring misconduct. *Nature*, 537(7618), 29–30.
- Lacetera, N. & Zirulia, L. (2011). The economics of scientific misconduct. *Journal of Law, Economics, and Organization*, 27(3), 568–603.
- LaFollette, M. C. (1992). *Stealing Into Print: Fraud, Plagiarism, and Misconduct in Scientific Publishing*. Berkeley and Los Angeles: University of California Press.
- Lanzafame, R. J. (2013). On Rejection, Resilience, and Retraction. *Photomedicine and Laser Surgery*, 31(1), 1–2.
- Lei, L., & Zhang, Y. (2017). Lack of Improvement in Scientific Integrity: An Analysis of WoS Retractions by Chinese Researchers (1997–2016). *Science & Engineering Ethics*, 24(5), 1409-1420.
- Liu, W., Hu, G., Tang, L., & Wang, Y. (2015). China's global growth in social science research. *Journal of Informetrics*, 9(3), 555–569.
- Lu, S. F., Jin, G. Z., Uzzi, B., & Jones, B. (2013). The retraction penalty: Evidence from the Web of Science. *Scientific Reports*, 3(1), 1-5.
- Luukkonen, T., Persson, O., & Silvertsen, G. (1992). Understanding patterns of international scientific collaboration. *Science, Technology, & Human Values*, 17(1), 101–126.
- Macfarlane, B., Zhang, J., & Pun, A. (2014). Academic integrity: A review of the literature. *Studies in Higher Education*, 39(2), 339–358.
- Magnetic Resonance in Medicine (2011). 65(3), 900-900, doi: 10.1002/mrm.22718
- McNutt, M.K., Bradford, M., Drazen, J.M., Hanson, B., Howard, B., Jamieson, K.H., Kiermer, V., Marcus, E., Pope, B.K., Schekman, R. & Swaminathan, S., (2018). Transparency in authors' contributions and responsibilities to promote integrity in scientific publication. *Proceedings of the National Academy of Sciences*, 115(11), 2557-2560.
- Melin, G., & Persson, O. (1996). Studying research collaboration using co-authorships. *Scientometrics*, 36(3), 363–377.

- 
- Merton, R. K. (1968). The Matthew effect in science: The reward and communication systems of science are considered. *Science*, 159(3810), 56-63.
- Mongeon, P., & Larivière, V. (2016). Costly collaborations: the impact of scientific fraud on co-authors' careers. *Journal of the Association for Information Science & Technology*, 67(3), 535–542.
- Nath, S. B., Marcus, S. C., & Druss, B. G. (2006). Retractions in the research literature: Misconduct or mistakes? *Medical Journal of Australia*, 185(3), 152–154.
- National Academies. (2014). *Science of Team Science*. Washington, DC: National Academies Press.
- Nature (2010). 467 (7317), 872-872. doi: 10.1038/nature09474
- Newman, M. (2001). The structure of scientific collaboration networks. *Proceedings of the National Academy of Sciences*, 98(2), 404–409.
- Noyori, R., & Richmond, J. P. (2013). Ethical conduct in chemical research and publishing. *Advanced Synthesis & Catalysis*, 355(1), 3–9.
- Nuclear Instruments and Methods in Physics Research. Section B, Beam Interactions with Materials and Atoms (2009). 267(20), 3491, doi:10.1016/j.nimb.2009.09.031
- Oransky, I. (2018). Volunteer watchdogs pushed a small country up the rankings. *Science*, 362 (6413), 395-395.
- Qu, S., & Wiwanitkit, V. (2015). Response to “The ethics of scholarly publishing: exploring differences in plagiarism and duplicate publication across nations”. *Journal of the Medical Library Association*, 103(1), 57–57.
- Riederer, B. M. (2014). Scientific misconduct and ethical aspects in publishing. *Laboratory Animals*, 48(3), 272.
- Schneider, J.W. (2011). Caveats, for using statistical significance tests in research assessments. *Journal of Informetrics*, 7(1), 50-62.
- Schneider, J. W. (2015). Null hypothesis significance tests. a mix-up of two different theories: the basis for widespread confusion and numerous misinterpretations. *Scientometrics*, 102(1), 411–432.
- Segal, A. (2011). *Advantage: How American Innovation Can Overcome the Asian Challenge*. New York: W. W. Norton & Company.
- Sheth, B. P., & Thaker, V. S. (2014). Scientific retraction: A synonym for pseudoscience? *Acta Bioethica*, 20(1), 93–97.
- Steen, R. G. (2011a). Retractions in the scientific literature: Do authors deliberately commit research fraud? *Journal of Medical Ethics*, 37(2), 113–117.
- Steen, R. G. (2011b). Retractions in the scientific literature: Is the incidence of research fraud increasing? *Journal of Medical Ethics*, 37(4), 249–253.
- Steen, R.G., Casadevall, A., & Fang, F.C. (2013). Why has the number of scientific retractions increased? *PLoS One*, 8(7), e68397. doi:10.1371/journal.pone.0068397.
- Stern, A. M., Casadevall, A., Steen, R. G., & Fang, F. C. (2014). Financial costs and personal consequences of research misconduct resulting in retracted publications. *Elife*, 3, e02956.
- Tang, L. (2019). Five ways China must cultivate research integrity. *Nature*, 575, 589-591.
- Trikalinos, N. A., Evangelou, E., & Ioannidis, J. P. A. (2008). Falsified papers in high-impact journals were slow to retract and indistinguishable from nonfraudulent papers. *Journal of Clinical Epidemiology*, 61(5), 464–470.

- 
- Uzzi, B., & Spiro, J. (2005). Collaboration and creativity: The small world problem. *American Journal of Sociology*, 111(2), 447–504.
- Van Raan, A. F. J. (1998). The influence of international collaboration on the impact of research results: Some simple mathematical considerations concerning the role of self-citations. *Scientometrics*, 42(3), 423–428.
- Walsh, J., Lee, Y., & Tang, L. (2019). Pathogenic organization in science: Division of labor and retractions. *Research Policy*, 48(1), 444–461.
- Wang, Q., Tang, L., & Li, H. (2015). Return Migration of the Highly-Skilled in Higher Education Institutions: A Chinese University Case. *Population Space and Place*, 21(8), 771–787.
- Wager, E., & Williams, P. (2011). Why and how do journals retract articles? An analysis of Medline retractions 1988–2008. *Journal of Medical Ethics*, 37(9), 567–570.
- Wilson, J. & Al, E. (2011). *Knowledge, Networks and Nations: Global Scientific Collaboration in the 21st Century*. London: The Royal Society.
- Wang, J., & Hicks, D. (2015). Scientific teams: Self-assembly, fluidness, and interdependence. *Journal of Informetrics*, 9(1), 197–207.
- Williams, P., & Wager, E. (2013). Exploring why and how journal editors retract articles: Findings from a qualitative study. *Science and Engineering Ethics*, 19(1), 1–11.
- Wuchty, S., Jones, B. F., & Uzzi, B. (2007). The increasing dominance of teams in production of knowledge. *Science*, 316(5827), 1036–1039.
- Yan, S., Rousseau, R., & Huang, S. (2016). Contributions of Chinese authors in PLOS ONE. *Journal of the Association for Information Science and Technology*, 67(3):543-549.
- Youtie, J., Rogers, J., Hinze, T., Shapira, P., & Tang, L. (2013). Career-based influences on scientific recognition in the United States and Europe: Longitudinal evidence from curriculum vitae data. *Research Policy*, 42(8), 1341–1355.
- Youtie, J., & Bozeman, B. (2014). Social dynamics of research collaboration: norms, practices, and ethical issues in determining co-authorship rights. *Scientometrics*, 101(2), 953–962.
- Zhang, M. H., & Grieneisen, M. L. (2013). The impact of misconduct on the published medical and non-medical literature, and the news media. *Scientometrics*, 96(2), 573–587.
- Zhou, P., Thijs, B., & Glänzel, W. (2009). Is China also becoming a giant in social sciences? *Scientometrics*, 79(3), 593–621.
- Zuckerman, H. (1988). The sociology of science. In Neil J. S(Ed), *Handbook of Sociology* (pp511–574). California: Sage Publications.

**Appendix 1 Detailed reasons of retraction and illustrative examples**

Type	Category	Judgment criteria	# Cases	Illustrative examples from retraction notices
1	Data fabrication/falsification	Manufacture of fictional data, selective manipulation of actual data to present a misleading result	369	“...The publisher hereby retracts the above article due to evidence of data manipulation, a clear violation of ASM’s ethical standards.” ( <i>Infection and Immunity</i> 2011, p. 545)
2	Plagiarism	Copying or closely imitating text, or using someone else's figures or images without assigning the appropriate credit	401	“...The author has plagiarized most of a paper that had already appeared in <i>Opt. Laser Technol.</i> , 40 (2008) 113–119, doi:10.1016/j.optlastec.2007.03.005.” ( <i>Nuclear Instruments and Methods in Physics Research. Section B, Beam Interactions with Materials and Atoms</i> 2009, p. 3491)
3	Suspected fraud	Though no explicit evidence indicating FFP by investigations, there are implications in the retraction notice such as “concerns of the data, unable to reproduce the findings or result”, “the data should not be considerable reliable”, “experiment unable to reproduce”, and so on.	366	“Three of the authors (J.L.S., F.S.K. and A.J.W.) wish to retract this Article after a re-examination of the publication raised serious concerns with some of the reported data. These concerns have undermined the authors’ confidence in the support for the scientific conclusions reported, specifically the role of osteopontin-positive niche cells in the rejuvenation of haematopoietic stem cells in aged mice. Although this matter is under further review, these authors wish to retract the paper in its entirety, and regret any adverse consequences that may have resulted from the paper’s publication.” ( <i>Nature</i> 2010, p. 872)
4	Duplicate submission /publication	Multiple submissions or publications. Articles already appeared in another journal before the second journal realized that the entire article is an exact duplicate or virtually identical to an article by the same authors in a different journal.	131	“The article was a duplication of a paper that had already appeared in COLSUB 4819 “Synthesis, characterization and comparison of antimicrobial activity of PEG/TritonX-100 capped silver nanoparticles on collagen scaffold”, <i>Colloids and Surfaces B: Biointerfaces</i> 90 (2012) 191–196. <a href="http://dx.doi.org/10.1016/j.colsurfb.2011.10.021">http://dx.doi.org/10.1016/j.colsurfb.2011.10.021</a> . The authors would like to apologize for this administrative error on their part.” ( <i>International Journal of Biological Macromolecules</i> 2013, p. 20)
5	Peer review manipulation	The process of peer review is manipulated	8	“This article has been retracted at the request of the Editor-in-Chief. A referee’s report on which the editorial decision was made was found to be falsified. The referee’s report was submitted under the name of an established scientist who was



				not aware of the paper or the report, via a fictitious EES account. Because of the submission of a fake, but well-written and positive referee's report, the Editor was misled into accepting the paper based upon the positive advice of what he assumed was a well-known expert in the field. This represents a clear violation of the fundamentals of the peer-review process, our publishing policies, and publishing ethics standards.” ( <i>Journal of Mathematical Analysis and Applications</i> 2013, p.456)
6	Author disputes	Disagreement of authorship such as leaving out significant authors, submission without consent of all coauthors, ghost authorship et al.	67	“The editors would like to confirm the retraction of this paper at the request of the authors. The corresponding author published the paper without the full consent or acknowledgement of all the researchers and would like to apologize for this error.” ( <i>Biochemical and biophysical research communications</i> 2009, p.464)
7	Copyright related	Copyright violation or confidential information disclosed	24	“This article has been retracted due to copyright issues.” ( <i>Indian Journal of Surgery</i> 2013, p.251)
8	IRB and ethics violation	Lack of approval of IRB or violation of ethics or professional regulations or journal policies	57	“This article has been retracted as the IRB approval for the research was misrepresented. The investigating committee at Klinikum Ludwigshafen found the lack of IRB approval and this is unethical. It does not mean that the research results per se are fraudulent.” ( <i>Intensive Care Medicine</i> 2011, p. 1231)
9	Funding related	Breach of funding agreement or not reporting funding agency.	2	“The following article from <i>Journal of Cutaneous Pathology</i> , “A preliminary examination of the role of NFAT 3 in human skin, cultured keratocytes and dermal fibroblasts” by Wael I. Al - Daraji, published online on 8 July, 2010 in Wiley Online Library ( <a href="http://onlinelibrary.wiley.com">http://onlinelibrary.wiley.com</a> ), has been retracted by agreement between the journal Editor in Chief, Timothy McCalmont, and Blackwell Publishing Ltd. The retraction has been made as the manuscript was submitted for publication in breach of an agreement with the University of Newcastle upon Tyne due to the failure to provide appropriate acknowledgement of sources.”( <i>Journal of Cutaneous Pathology</i> 2010, p.1190)
10	Multiple infractions	More than one reason leading to the final retraction of paper	129	“The authors have retracted this article [1] as there was a large overlap with a previously published article in <i>International Journal of Cancer</i> [2]. Dr Lu

				ShihHsin, although listed as an author, was not aware of the publication in <i>Journal of Experimental &amp; Clinical Cancer Research</i> and the grant reference number stated in the acknowledgements was incorrectly applied to this article.” ( <i>Journal of Experimental &amp; Clinical Cancer Research</i> 2011, p.19)
11	Scientific error	Erroneous interpretations of experimental results, technical mistakes or inaccuracies, contaminated reagents without evidence of intentional deception or falsification	302	“This article has been retracted at the request of the authors and/or the Editor-in-Chief. Reason: The main theorem of the paper, Theorem 4.1, contains serious technical mistakes which cannot be fixed. At the request of the authors and with the concurrence of the editors, this article has been retracted.” ( <i>Journal of Mathematical Analysis and Applications</i> 2011, p.403)
12	Publisher error	Duplicate, wrong versions, or other production mistakes due to administrative errors of publishers	54	“...The retraction has been agreed due to the article having been published twice as a result of a publisher error and through no fault of the authors, with the correct version appearing in <i>Magnetic Resonance in Medicine</i> , Volume 64, Issue 3, pages 698–706.”( <i>Magnetic Resonance in Medicine</i> 2011, p.900)
13	Unknown	Not enough information to classify	178	“The above article and its contents are hereby retracted by agreement among the authors, the Editor of the <i>Journal of Applied Physics</i> , and the American Institute of Physics.”( <i>Journal of Applied Physics</i> 2011, p. 109903)

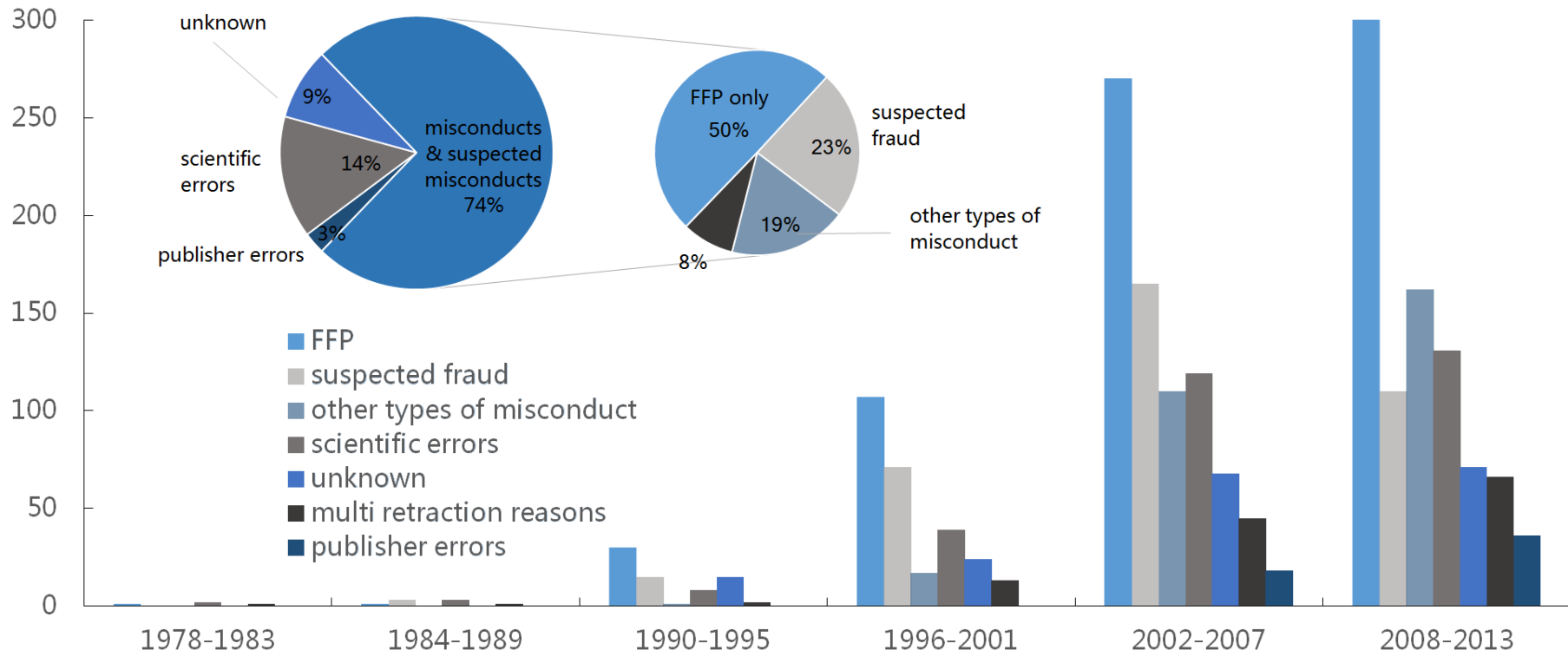
Sources: Authors' research.

Appendix 2. Numbers and Shares of Retractions by Selected countries

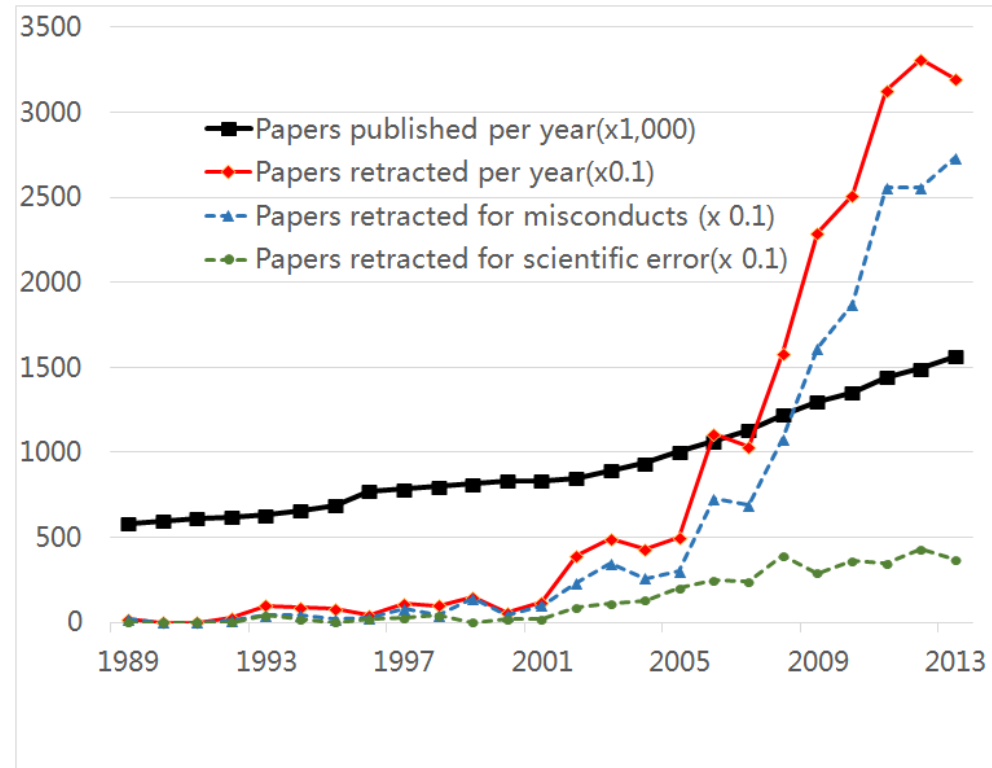
Ranking By Retractions	# Retracted Pubs	Country	# WoS Pubs	#Retracted/#WoS Pubs (%)
1	622	USA	9116071	0.68
<b>2</b>	<b>341</b>	<b>China</b>	<b>1580103</b>	<b>2.16</b>
3	263	Japan	1988901	1.32
4	184	Germany	1708627	1.08
<b>5</b>	<b>141</b>	<b>India</b>	<b>729208</b>	<b>1.93</b>
6	123	UK	2299882	0.53
<b>7</b>	<b>110</b>	<b>South Korea</b>	<b>501785</b>	<b>2.19</b>
8	76	Netherlands	640067	1.19
9	56	France	1539715	0.36
10	53	Italy	1018887	0.52
11	49	Australia	770478	0.64
11	49	Canada	1265552	0.39
<b>13</b>	<b>46</b>	<b>Iran</b>	<b>155727</b>	<b>2.95</b>
14	35	Spain	736498	0.48
15	33	Turkey	265099	1.24
<b>16</b>	<b>29</b>	<b>Egypt</b>	<b>95459</b>	<b>3.04</b>
17	28	Sweden	481303	0.58
18	27	Taiwan	340364	0.79
19	22	Switzerland	468366	0.47
20	20	Singapore	124129	1.61
21	18	Brazil	421151	0.43
22	14	Finland	221826	0.63
23	12	Austria	232357	0.52
24	11	Greece	168326	0.65
24	11	Israel	305054	0.36
26	10	Ireland	102589	0.97
26	10	Thailand	63580	1.57

Source: Authors' data collection from WoS.

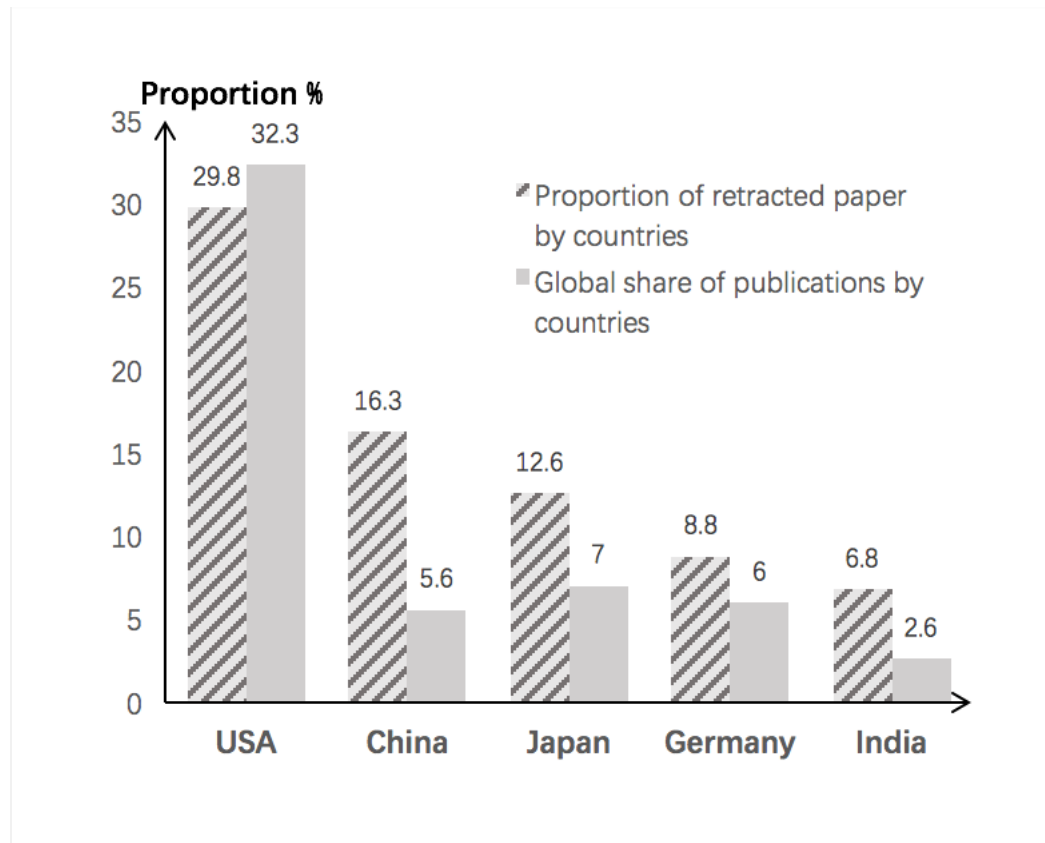
Figure 1. Shares and dynamics of retraction reasons



Source: Authors' data collection from WoS.

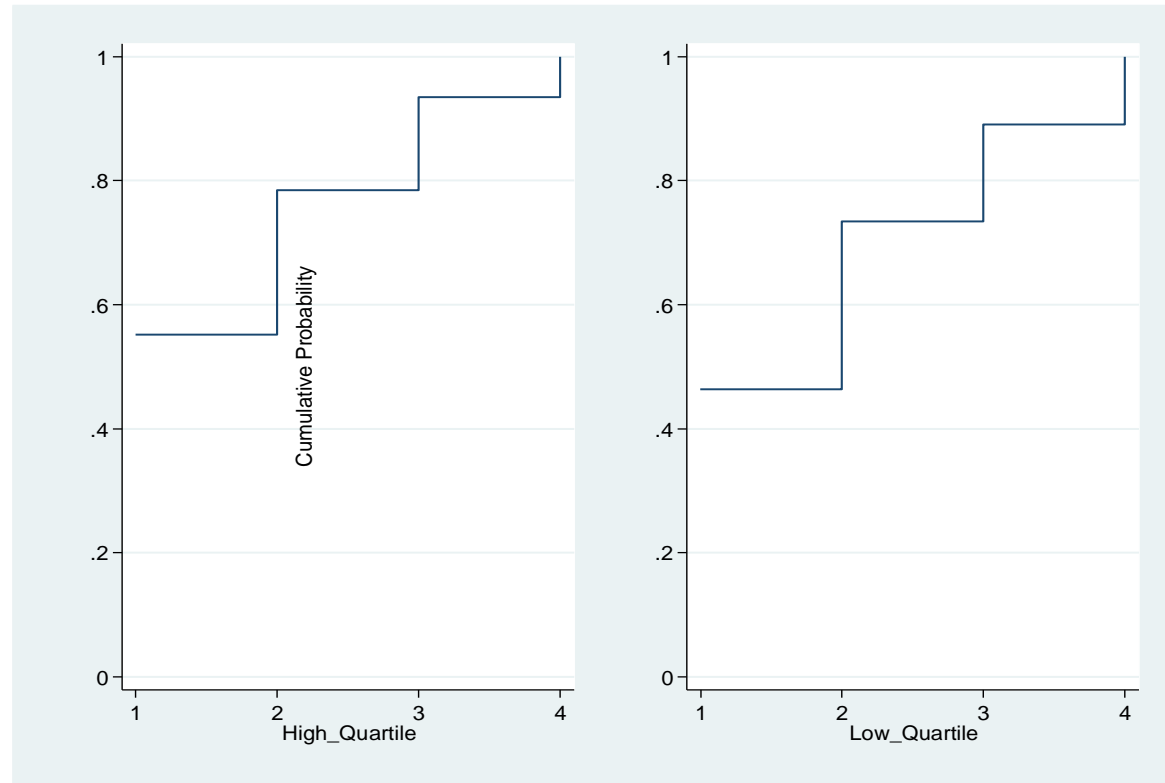
**Figure 2. Evolution of publication and retraction in WoS**

Source: Authors' data collection from WoS.

**Figure 3. Article distribution by selected countries: Retracted articles vs all WoS articles**

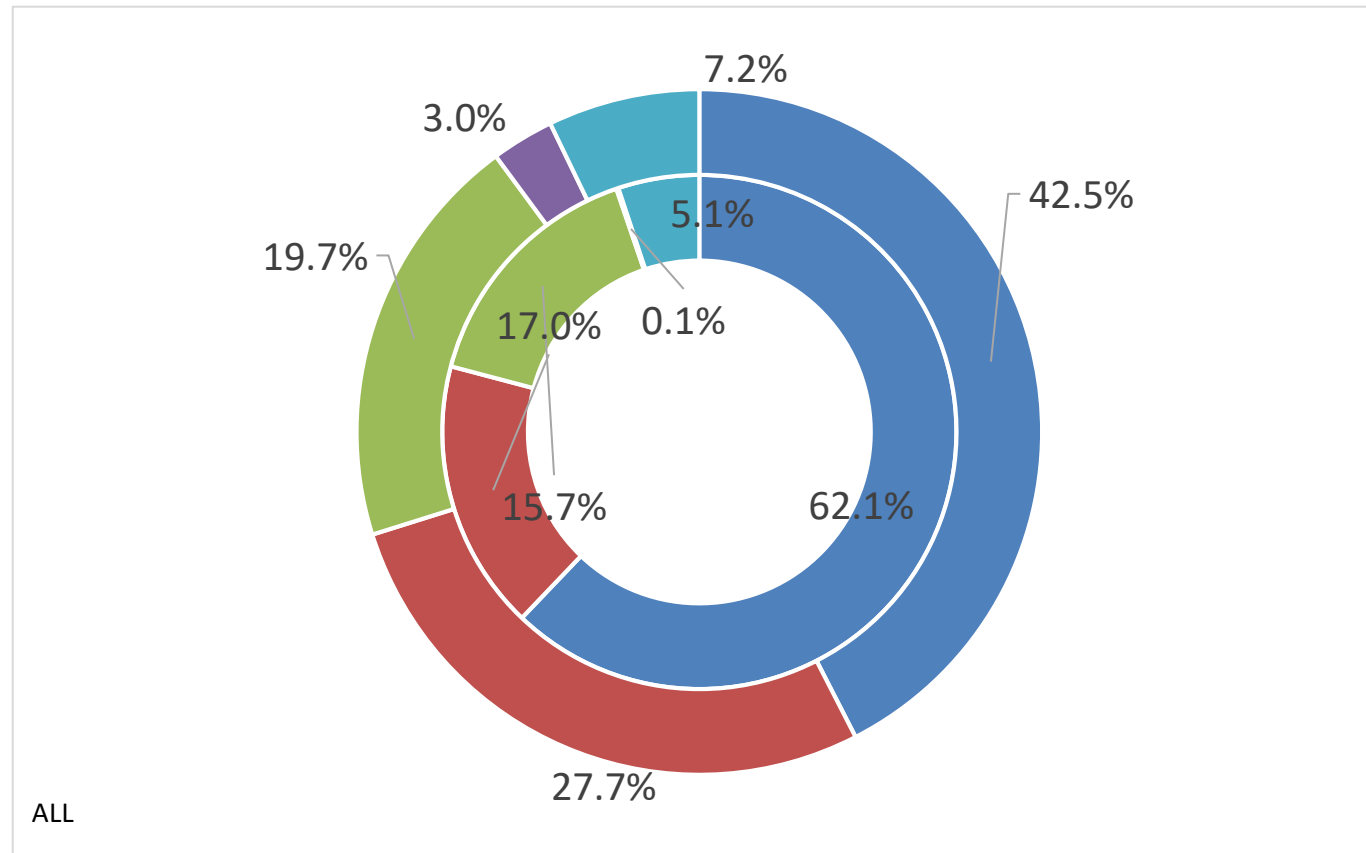
Note: WoS indexed records were retrieved on June 18, 2016. The global shares were calculated by the authors.

**Figure 4. Distribution of journal impact factors of retracted articles by quartile**



Source: Authors' data collection from WoS.

**Figure 5. Article distribution by research areas: Retracted articles vs all WoS indexed articles**



■ Life science & biomedicine ■ Physical sciences ■ Technology ■ Arts & humanities ■ Social sciences

Note: WoS indexed records were retrieved on June 18, 2016. The global shares were calculated by the authors.

Inner circle: The proportion of retracted papers by discipline.

Outer circle: All WoS indexed articles by discipline.



**Table 1. Repeat offenders**

#	Author Names	Affiliated Country	#Retracted	Research domain	Authorship in retractions	Sex	Major reasons for retraction
1	Fujii, Yoshitaka	Japan	86	Life sciences	Fujii is the corresponding author of 83 of 86 retracted articles	M	Manipulated the research period on purpose, suspected misconduct, failed to obtain IRB approval
2	Toyooka, Hidenori	Japan	67	Life sciences	All of Toyooka's 67 retracted articles are collaborated with Fujii. He is neither the corresponding author nor the first author.	M	Manipulated the research period on purpose, suspected misconduct, failed to obtain IRB approval
3	Tanaka, Hiroyoshi	Japan	53	Life sciences	All of Tanaka's 53 retracted papers are collaborated with Fujii. He is neither the corresponding author nor the first author.	M	Manipulated the research period on purpose, suspected misconduct, failed to obtain IRB approval
4	Stapel, Diederik A	The Netherlands	42	Psychology	In 18 out of 42 retractions Stapel is the reprint author.	M	Fraudulent data or fictitious studies
5	Boldt, Joachim	Germany	37	Life sciences	In 14 out of 37 retractions Boldt is the reprint author.	M	Lack of IRB approval, no ethical approval or advice as required by law
6	Mori, Naoki	Japan	30	Life sciences	Mori is the reprint author of all 30 retractions.	M	Data manipulation and self-plagiarism
7	Schön, Jan Hendrik	U.S. <sup>20</sup>	27	Physics	In 21 of 27 retractions Schön is the reprint author.	M	Falsification or fabrication of data
8	Saitoh, Yuhji	Japan	26	Life sciences	In 3 of the 26 retracted articles Saitoh is the reprint author. All retractions were coauthored with Fujii.	M	Manipulated the research period on purpose, suspected misconduct, failed to obtain IRB approval
9	Piper Swen N	Germany	22	Life sciences	In 10 retractions Piper is the reprint author, and 20 were coauthored with Boldt.	M	Lack of IRB approval
10	Kloc, Christian	U.S. <sup>21</sup>	20	Physics	In all 20 retracted articles coauthored with Schön, Kloc is neither the corresponding author nor the first author.	M	Concerns about the validity of data associated with the device measurements described in the paper

<sup>20</sup> Schön, J H was born and received his Ph.D. in Germany, but all of his retracted articles were affiliated with Bell Labs in the US.

<sup>21</sup> Kloc was born and received his Ph.D. in the Republic of Poland, but all his involved retracted articles were affiliated with Bell Labs in the U.S.

**Table 2. Collaboration size (authors, institutions, countries) for retracted papers and control group,  
including time to retraction for retracted papers**

N=6057

	Number of Authors				Number of Affiliations			
	Min	Mean	Median	Max	Min	Mean	Median	Max
<b>Retracted</b>	1	4.95	4	32	1	1.92	2	16
<b>Control</b>	1	5.36	5	53	1	2.14	2	30
	Number of Countries				Time to Retraction (months)			
	Min	Mean	Median	Max	Min	Mean	Median	Max
<b>Retracted</b>	1	1.24	1	8	0.00	39.14	23.00	325.00
<b>Control</b>	1	1.29	1	12	N/A	N/A	N/A	N/A

**Table 3 Factors influencing the likelihood of retractions by logistic regressions: 1978–2013**

	Odds Ratio [95% Conf. Interval]					
	Panel 1: All retractions and matched papers considered			Panel 2: Only retractions for FFP and matched papers considered		
Number of Authors	0.95 [0.94-0.97]***			0.95 [0.92-0.98]***		
Number of Affiliations	0.92[0.88-0.96]***			0.97[0.91-1.04]		
Number of Countries	0.95[0.87-1.04]			1.04[0.89-1.21]		
Author Top-100 Univ.	0.77[0.67-0.88]***	0.78[0.68-0.90]***	0.75[0.65-0.86]***	0.63[0.50-0.79]***	0.62[0.49-0.78]***	0.60[0.47-0.76]***
Primary Author USA	1.12[0.97-1.29]	1.10[0.95-1.27]	1.12[0.97-1.30]	0.85[0.67-1.08]	0.85[0.67-1.09]	0.86[0.68-1.10]
<b>Primary Author China</b>	<b>2.18[1.82-2.61] ***</b>	<b>2.08[1.74-2.49] ***</b>	<b>2.10[1.76-2.52] ***</b>	<b>2.38[1.78-3.17] ***</b>	<b>2.29[1.71-3.05] ***</b>	<b>2.30[1.72-3.07] ***</b>
Primary Author Japan	1.92[1.58-2.32] ***	1.83[1.52-2.22] ***	1.82[1.50-2.20] ***	<b>3.62[2.71-4.82] ***</b>	<b>3.44[2.58-4.57] ***</b>	<b>3.45[2.59-4.59] ***</b>
Primary Author Germany	1.66[1.32-2.09] ***	1.62[1.29-2.04] ***	1.64[1.30-2.06] ***	1.34[0.90-1.99]	1.30[0.88-1.94]	1.30[0.88-1.94]
<b>Primary Author India</b>	<b>2.96[2.27-3.87] ***</b>	<b>2.94[2.25-3.84] ***</b>	<b>3.01[2.31-3.93] ***</b>	<b>4.75[3.23-6.97] ***</b>	<b>4.75 [3.24-6.97] ***</b>	<b>4.81[3.28-7.07] ***</b>
Publication Year	1.00[0.99-1.01]	1.00[0.99-1.01]	1.00[0.99-1.01]	1.01[0.99-1.03]	1.01[0.99-1.03]	1.00[0.98-1.02]
Impact Factor	1.01[1.00-1.02]***	1.01[1.00-1.02]**	1.01[1.00-1.02]**	1.03[1.02-1.04]***	1.03[1.02-1.04]***	1.02[1.00-1.04]***
Research Areas	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
N	6049	6049	6049	2464	2464	2464
Pro>chi <sup>2</sup>	0.0000	0.0000	0.0096	0.0000	0.0000	0.0000
Pseudo R <sup>2</sup>	0.026	0.025	0.023	0.067	0.064	0.064

**Note:** \* Significance at 10% level; \*\* Significance at 5% level; \*\*\* Significance at 1% level.

Table 4 Factors influencing the time to retraction by using OLS regressions: 1978–2013

	Coef. (Std. Err.)					
	Panel 3: All retraction reasons considered			Panel 4: Only Retraction due to FFP considered		
Number of Authors	0.02 (0.01)**			-0.00 (0.01)		
Number of Affiliations		0.02 (0.02)			0.02 (0.02)	
Number of Countries			0.03 (0.04)			0.07 (0.05)
Author Top-100 Univ.	-0.11 (0.05)**	-0.11 (0.05)**	-0.10(0.05)**	0.01 (0.08)	-0.01 (0.08)	-0.02(0.08)
Primary Author USA	0.08 (0.05)	0.09 (0.06)	0.08 (0.06)	0.13 (0.06)	0.14 (0.08)	0.14 (0.08)
<b>Primary Author China</b>	<b>-0.11(0.06)*</b>	<b>-0.10(0.06)</b>	<b>-0.10(0.06)</b>	<b>-0.23(0.09)**</b>	<b>-0.23(0.09)**</b>	<b>-0.22 (0.09)*</b>
Primary Author Japan	0.57(0.07)***	0.58(0.07)***	0.58(0.07)***	0.58(0.09)***	0.58(0.09)***	0.59(0.09)***
Primary Author Germany	0.39(0.08)***	0.40(0.08)***	0.40(0.08)***	0.16(0.13)	0.16(0.13)***	0.40(0.08)***
<b>Primary Author India</b>	0.09(0.08)	0.10(0.08)	0.09(0.08)	0.08(0.10)	0.08(0.10)	0.08(0.10)
Publication Year	-0.12(0.00) ***	-0.12(0.00) ***	-0.12(0.00) ***	-0.14(0.01) ***	-0.14(0.00) ***	-0.14(0.01) ***
Journal Impact Factor	-0.01(0.00) ***	-0.01(0.00) ***	-0.01(0.00) ***	-0.02(0.01) ***	-0.02(0.00) ***	-0.02(0.01) ***
Research Areas	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
<b>Retraction due to FFP</b>	<b>0.31(0.04) ***</b>	<b>0.31(0.04) ***</b>	<b>0.31(0.04) ***</b>			
N	2084	2084	2084	850	850	850
Pro>F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R <sup>2</sup>	0.374	0.373	0.373	0.523	0.523	0.517

Notes: \* Significance at 10% level; \*\* Significance at 5% level; \*\*\* Significance at 1% level.