Retraction: The Other Face of Research Collaboration

Li Tang[a,*], Guangyuan Hu[b], Yang Sui[c], Cong Cao[d,*]

[a] School of International Relations and Public Affairs, Fudan University, Shanghai, China, 200433, email: litang@fudan.edu.cn

[b] Shanghai University of Finance Economics, Shanghai, China, 200433, email: hu.guangyuan@shufe.edu.cn

[c] Kearney A.T., Shanghai, China, 200433, email: suiyanghi@126.com

[d] Faculty of Humanities and Social Sciences, University of Nottingham Ningbo China, 315100, email: cong.cao@nottingham.edu.cn

[*] Authors for correspondence

Acknowledgment: This research draws on support from the National Natural Science Foundation of China (#71303147) and Shanghai Soft Science Program (#14692102900). The conclusions contained herein are those of the authors and do not reflect the views of funders.

Retraction: The Other Face of Research Collaboration

Abstract: There is an increasing amount of research investigating retractions. Yet little attention has been paid to the relationship between retractions and collaboration. This study draws upon two notions from the social psychological literature on group interaction – diffusion of responsibility and internal auditing – to examine the effect of collaboration size on retraction. We test our hypotheses regarding the relationship between retractions and collaboration on a unique publication dataset of retractions and its control group constructed by the nearest-neighbor-matching approach. Our analysis does not support the diffusion of responsibility as no significant evidence indicates that collaboration suffers from producing flawed research, at least in the form of retraction. We also find that *ceteris paribus* publications with authors from elite universities are less likely but quickly to be retracted. There also is no significant impact of collaboration size on the speed of retraction of Chinese articles, although China stands out with the fastest retracting speed. Our findings have policy implications for the governance of global science, especially that involves collaboration.

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

Retraction: The Other Face of Research Collaboration

1. Introduction

Team-dominated knowledge production has become ubiquitous globally. The trend of co-publishing escalating is evidenced by steadily growing team size and proportions of multi-authored publications, many of which are across nation's borders (LaFollette, 1992; Cronin, 2001; Newman, 2001; Wuchty et al., 2007; Royal Society, 2011; National Academies, 2014). Reasons for producing joint research vary, from greater epistemic authority (Beaver & Rosen, 1979), more easily secured funding (Melin & Persson, 1996), higher-quality work due to cross-pollination of different minds (Cronin, Shaw, & Barre, 2004; Youtie et al., 2013), to possibility of the work receiving more citations (Royal Society, 2011). Meanwhile, the number and the annual rate of retraction of scientific research, or the official declaration of withdrawal of an article from the literature for scientific misconduct or significant errors, also have surged exponentially over the last decade (Steen, 2011a; Van Noorden, 2011; Zhang & Grieneisen, 2012; Riederer, 2014; Sheth & Thaker, 2014). The seeming coincidence, or at least co-concurrence, of the rising collaboration and retraction raises following questions: Is teamwork more likely to be associated with retraction? What contributes to the elapsed time between publication and retraction of collaborative work?

Unfortunately, in spite of extant research that examines factors impacting retraction, within our best 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 effect of collaboration – type and size – on retraction. To do so, we draw on two opposite notions from the social psychological literature on group interaction – diffusion of responsibility and internal auditing – and test our hypotheses regarding the relationship between retraction and collaboration on a unique publication dataset of retractions and its control publication dataset constructed by the nearest-neighbor-matching approach. There is evidence in support of teamwork premium inhibiting retraction; *ceteris paribus* publications with authors from elite universities are less likely but quickly to be retracted; and among existing and emerging scientific powers measured by the number of publications, China stands out with the fastest retracting speed. These findings will have policy implications for the enhancement of the governance of knowledge production in collaborative research.

The rest of the paper is structured as follows: Section 2 highlights topic importance and some noteworthy studies on retraction, while Section 3 delineates key notions and hypotheses for testing. Section 4 outlines the data and methodology, followed by analysis in Section 5. Major findings and policy implications are discussed in Section 6.

2. 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 now increasingly dependent on the findings from scientific research, thus rendering scientific rigor and research integrity more important than ever (Macfarlane, Zhang, & Pun, 2014). Policy makers and research administrators come to realize that fraudulent findings endanger not only the operation of scientific enterprise but also the wellbeing of the society at large, not to mention wasting escalating but still scarce public investment[1] and tarnishing the trust of the public toward science and scientists (Zuckerman, 1988; Lacetera & Zirulia, 2011; Azoulay et al., 2012; Steen 2014). Unsurprisingly, over the last decade, a growing number of studies have investigated the rising phenomenon of retraction, from which four major research streams have emerged (Appendix 1 summarizes the main findings of recent empirical studies).

The first line of research describes the phenomenon. Studies consistently show that both the number and the growth rate of retracted articles have risen sharply over the last decade (Nath et al., 2006), and that such phenomenon has a strong national orientation (Liu & Hu, 2012). While research seems to suggest a high incidence of retractions in articles indexed in PubMed, a biomedical database, anecdotal evidence indicates that publishing misconduct is significantly greater in non-PubMed articles than in PubMed ones (Zhang & Grieneisen, 2013). Grieneise and Zhang (2012) also argued convincingly that repeat retractors are globally distributed and have skewed distribution at country and institutional levels. Retraction is particularly prevalent for research produced in countries such as the USA,

[1] For example, Steen (2014) established that on average each retracted article funded by the National Institutes of Health between 1992 and 2012 incurred an average direct cost of $392,582.

Germany, Japan, China, the UK, and India.[2] For example, China leads in duplicate publications, followed by the USA and India (Grieneise & Zhang, 2012).

The second line of research categorizes reasons for retraction for the sake of policy prevention and intervention. Wager and Williams (2011; 2013) pointed out that reasons for retraction vary, including but not limited to honest research errors, redundant publications, and plagiarism. Steen (2011b) further concluded that about three quarters of the retracted PubMed papers between 2000 and 2010 are due to errors or undisclosed reasons. Fang et al. (2012) refined previous research on causes of retraction. By combining information from Retraction Watch, the US Office of Research Integrity (ORI), and other public sources, they reported that only one fifth of the retractions resulted from errors, whereas over two thirds of the papers were removed because of scientific misconduct manifested in falsification, fabrication, and plagiarism.[3] Nath et al. (2006) performed a study to determine how commonly articles had been retracted on the basis of unintentional mistakes and whether such articles had differed from those retracted for scientific misconduct in authorship, funding, type of study, publication, and time to retraction. One consistent finding is that the number of retractions was correlated significantly with impact factors of the journal in which the retracted paper was published. Steen (2011b) also argued that journal's impact factors were often significantly higher for fraudulently produced papers. And Noyori and Richmond (2013) confirmed empirically that the higher the impact factor of a journal, the more cases of retractions there were.

The third strand of investigation explores the retraction phenomenon from the perspective of scientists. For example, Lacetera and Zirulia (2011) proposed a game-theoretic model to help understand motivations of scientists committing fraud as well as approaches of

[2] The ranking order of these countries changes a bit depending on the coverage of retraction articles analyzed.

[3] Different samples and coding schemes are the two main reasons accounting for the different results between Steen (2011b) and Fang et al. (2012). First, while both used PubMed as data sources, Steen (2011b) covered about 800 retracted articles between 2000 and 2010 and Fang et al. (2012) looked at some 2000 retracted articles between 1973 to May 2012. Second, Steen (2011b) collapsed "undisclosed reasons" of retraction to the category of errors based on retraction notices, while Fang et al. (2012) improved the research by combining information from ORI. Please note Steen also is a co-author of Fang et al. (2012).

detecting and preventing fraud. By setting retraction in a dynamic game with asymmetrical information, they found that elite scientists were more likely to commit scientific misconducts but were less likely to be spotted than average misbehaved scientists. They also suggested that more intensive competition might in fact reduce scientific malfeasance because competitors closely monitor new findings.

Recently, studies have appeared treating the event of retraction as an independent variable and examining its impact on the individual and research domain levels. For example, Azoulay et al. (2012) investigated the extent to which false science impacts the rate and the direction of scientific change. Lu et al. (2013) also looked at how the retraction event impacted citations through comparing an expanded treatment group, which includes not only retracted articles but also prior articles of the retracted researchers, and a control group, which consists of papers with similar citation patterns to treated papers prior to the date of retraction. They found that citation penalty for non-self-reporting retraction goes beyond the retracted paper itself. Along this line to investigate the impact of retraction on the citations to retracted authors' prior work, Jin et al. (2013) documented a heterogeneous impact of retraction penalties on eminent and less-famous collaborators. The reverse Matthew Effect, in their words, hints at protection of established reputations.

The current study continues these inquiries following especially research streams one and three. One research gap that we spotted is a possible connection between co-publishing and retraction. In a departure from past scholarship, we try to understand the mechanism that governs the behavior of individuals in research collaboration. In particular, we are interested in knowing whether working together helps encourage responsible publishing effort.

3. Theories and hypotheses

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 with the presence of others, as the individual assumes that others either are responsible for taking action or have already done so (Darley & Latane, 1968; Forsyth et al., 2002). This bystander inaction could also occur in real-life academia. In the case of joint publication, for example, it is reasonable to assume that each coauthor feels that the responsibility for credibility and quality of the coauthored work is diffused, thus not necessarily taking care of the validity of the collective knowledge product.

A closely related but different notion is social loafing (Williams & Karau, 1991). That is, team members can become disgruntled and de-incentivized by unfair workload distribution due to social loafing (Tsai & Chi 2008). In the case of scientific collaboration, social loafers contribute less than their fair share to collective efforts but reap the benefits of the efforts of group members as the entire group is rewarded or punished by new knowledge demonstrated in the joint publication (Aggarwal & O'Brien, 2008).

This underperformance due to diffusion of responsibility and social loafing, combined with the cost of collaboration (such as knowledge fragmentation and coordination failure), thus increases the likelihood of producing flawed scientific findings, which, in return, leads to a higher probability of retraction. Accordingly, our first hypothesis is as follows:

- *Hypothesis 1a: As the size of the coauthorship increases, there will be greater incidence of retraction.*

In contrast to diffusion of responsibility embedded in the social loafing theory, internal auditing, which is linked to the social interdependence theory (Johnson, 2003), provides an alternative scenario. Conceivably, due to internal auditing, more coauthors may mean a higher likelihood of carrying out more scrupulous checking and knowledge validation and ensuring higher standard of quality control, thus leading to robust research that is less likely to be retracted. In other words, without collaborators' internal auditing, a single author might be more likely to produce sloppy or even false work. So, our alternative hypothesis is:

- *Hypothesis 1b: The size of coauthorship is negatively associated with the possibility of retraction holding other things constant.*

Factors impacting retractions

While Pozzi and David (2007) reported a lag of three years for investigated retractions by the US ORI, Redman et al. (2008) documented a much shorter retraction time – 20.75 months on average – in their study of the 315 retracted papers in the 1995–2004 PubMed data. However, existing research has paid very little attention to the factors impacting the time between publication and retraction, with few notable exceptions. A recent study conducted by Furman and colleagues (2012), for example, argued that no observable factors impacted 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.

Intuitively, multi-authored research on average receives more scholarly attention and scrutiny and thus is possibly quick to be detected for its shaky or fraudulently produced findings. So our second null and alternate hypotheses are:

- *Hypothesis 2a: The size of coauthorship is positively associated with the elapsed time between publication and retraction.*
- *Hypothesis 2b: The size of coauthorship is negatively associated with the time between publication and retraction.*

4. Methodology

In order to test our hypotheses, we first constructed datasets in a series of sequential steps. Our primary source is a retracted paper dataset retrieved from Thomson Reuters' Web of Science (WoS), an index of 11,600 peer-reviewed journals world-wide with coverage spanning a wide range of scientific disciplines. To develop this dataset, we started with using a composite Boolean query to search retraction notices, from which we eventually identified 2,087 unique retracted papers then downloaded the full bibliographical records of the retracted articles indexed in WoS from 1978 to 2013.[4] Only original research articles were included in our dataset. We consider this a more up-to-date dataset than not only that built on PubMed, the database adopted by most previous studies, but also that utilizing information from WoS. Therefore, our dataset reveals a more comprehensive picture of the retraction phenomenon and especially the factors that have impacted retractions.

Based on the nearest-neighbor-marching principle proposed by Furman et al. (2012), we additionally identified two control articles for each retracted one by choosing its nearest

[4] We searched "retract*" in the fields of title, key words and abstract and confined to the document type of corrections for the period from 1978 to 2013. For each retrieved hit, we linked to its retracted article. After several rounds of independent verification and cross-checking of two team members, 2,087 unique retraction notices and their corresponding retracted articles were identified and downloaded in January 2014.

neighbors. We started with the two articles immediately before and after the retracted article in the same issue of the same journal in which the retracted article was published. If neither one is qualified (for example, its document type is conference abstract, letter, correction, and editorial, among others), we next tried its nearest neighbor. The farthest neighborhood distance is 3, i.e. three papers ahead of or behind the retracted one, and we stopped search if we still were unable to locate matching articles. If a retracted article was the first or last one in that issue, we only included one comparison. In this way, we finally identified 3,970 control records with 96.6% matching rate.[5] This approach of matching baseline of journal and publication time has an explicit and effective merit as it holds constant other factors that might have potentially affected the incidence of retraction.

The two datasets were then imported into the text mining software VantagePoint. Scrupulous care was taken to complete several rounds of data cleaning and standardization. Our final core dataset for analysis consists of 6,057 records with 2,087 retracted articles and 3,970 associated control matched articles. We further retrieved journal impact factors from the 2013 ISI Journal Citation Reports (JCR)[6] and global rankings of the institutional affiliations of the authors of the retracted and control articles from the 2014 Academic Ranking of World Universities (ARWU) released by Shanghai Jiaotong University and merged them into our dataset.[7]

5. Analysis

Descriptive analysis

Our data indicate that between 1978 and 2013, both retraction quantity and rate increased with time. Measured by the year when the retracted articles were published, only three retractions appeared in 1978 publications, but retractions rose to 198 in 2000 and 213 in

[5] Among them 60 retracted articles have one single match for each.

[6] Considering the journal coverage dynamics of WoS, if the impact factor is not available in JCR 2013, we used its latest available impact factor. For example, one retracted article was published in the *Japanese Journal of Medical Science & Biology* (ISSN 0021-5112), whose latest impact factor is 0.444 in JCR 2000; thus we used that value as the journal's impact factor.

[7] For consistency, non-university institutions such as the Chinese Academy of Sciences and US national labs were treated as non-elite.

2010. According to the year of retraction notices, the frequency of retraction appears to be precipitous, yet the publications between 2010 and 2013 were retracted more than ten times those between 2000 and 2003.

We calculated the subject-specific quartile impact factors of each journal based on the 2013 ISI JCR. If a journal is assigned to different subject categories or disciplines, we took its impact factors at both the highest and lowest quartiles (Liu and Hu, 2016). Consistent with previous findings, our analysis indicates that retractions appeared substantially more frequent in journals with higher impact factors. As illustrated in Figure 1, even in the pessimistic mode of taking the lowest quartile, 46% of the retracted articles were published in Quartile-1 (high-impact-factor) journals while only 11% in Quartile-4 (low-impact-factor) journals. In the optimistic mode of allocating journal's impact-factor quartiles, the retractions were 55% in Q1 but 7% in Q4.[8]

[Figure 1 inserted here]

With regard to research domains, retraction was more common in hard sciences, especially in the biomedical and life sciences, similar to Lu's findings (2013), although Lu's research only focused on post-2000 WoS retracted articles. As illustrated in the inner circle of Figure 2, over 60% of the retracted articles were in the life sciences & biomedicine; by sharp contrast, only 0.1 % of the arts & humanities papers and 5.1 % of the social sciences papers were retracted. The highly uneven distribution of retractions across different disciplines may reflect lower incidences of false science or lower rates of detection of problematic research in the arts & humanities and social sciences where knowledge validation norms may differ. We then benchmarked the distribution of retracted articles against all publications in five research areas between 1990 and 2013 (shown in the outer circle of Figure 2). Apparently, the proportion of retracted life sciences & biomedicine articles is one third more than their share in the WoS articles, which only contributed 42.5% of the indexed publications.[9] The leading

[8] For example, if a retracted article was published in *Acta Neurochirurgica* (ISSN: 0001-6268), the journal's impact factor in the year of 2014 is 1.766, which ranked it the 124th among 192 journals in the field of clinical neurology, i.e. the third quartile in pessimistic mode, and 84/198 in surgery, i.e. the second quartile in optimistic mode.

[9] Only four document types – article, review, note, and letter – are considered in our record retrieving and calculation.

scientific nations of the USA, China, Japan, Germany, and India all witnessed a higher proportion of retractions in the life sciences & biomedicine relative to their shares of papers in this research domain. The enormous consequences and economic potential of the research in these fields as well as fierce competition for positions, promotions, funding, and especially priority of discovery and peer recognition might lead life scientists to rush to publish, thus also subjecting their research to more scrutiny.

[Figure 2 inserted here]

The distribution of flawed research also is highly skewed nationally. The top five countries in terms of the number of retracted articles were the USA (622), China (341), Japan (263), Germany (184), and India (141). As shown in Figure 3, the USA published and retracted almost similar percentages of papers; China, Japan, and Germany each produced some 7% of the global WoS papers, but China and Japan retracted much higher percentages of papers than Germany; and the India's share of its retracted papers was 2.5 times its share of the global WoS papers.

[Figure 3 inserted here]

Table 1 compares the collaboration size (number of authors, number of affiliations, and number of countries) and time to retraction for retracted vs. control paper groups. Apparently, at all three dimensions of author, affiliation, and country, retracted articles have smaller scopes of collaboration. We particularly took a close look at China by extracting out a sub-sample of 341 retracted articles matched with 629 comparisons.[10] As shown in Figure 4, there is no significant difference in collaboration size between the Chinese and global retractions, but the time to spot and retract flawed research involving Chinese researchers was much shorter: the median time for the Chinese retractions was 12 months, which is about half of that for the global retractions. Next we examined whether such difference is statistically significant controlling for other factors.

[Table 1 inserted here]

[Figure 4 inserted here]

[10] Among 341 retractions involving scholars from China, 310 have Chinese primary authors, including 303 reprint authors and 7 first authors.

Regression analysis

Dependent variables

Our unit of analysis is 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 the article's publication and retraction.[11]

Explanatory variable

The major independent variable of the study is collaboration size. Following common practices, we measured collaboration size 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

Control variables

In addition to year of publication, research domain, and journal's impact factor, which are explicitly controlled by our nearest-neighbor-matching approach, as explained, we also controlled for research environment by adding a dummy variable indicating affiliation of any author or any primary author (i.e. first author and reprint author) with a global elite or Top-100 university on the 2014 Academic Ranking of World Universities. The logic is very simple: scholars from elite universities are more likely to care about their academic reputations and those of their institutions as well as the devastating ramifications of retraction for their career. Additionally, we added a set of primary country dummy variables to the regression models to control for the research culture factor.

[11] There are 108 retracted articles with missing values of the publication month for either retracted article or retracted notice. We estimated their elapsed months by assuming the same month of publication and retraction.

For testing Hypothesis 1 we used logistic regressions while OLS regressions using the natural logarithm of the time-to-retraction in months were adopted for testing Hypothesis 2. Our primary results are presented in Tables 2 and 3 (in both tables, Panels 1 and 3 are for the global dataset while Panels 2 and 4 zoom in the China sub-dataset). Whole counting was adopted here, as there is no one-to-one link between authors and their reported institutions for multi-authored publications indexed in WoS (Agrawal, McHale, & Oettl, 2013).

[Table 2 inserted here]

[Table 3 inserted here]

Three findings on global retractions are worthy of noting (see Panels 1 and 3 of Table 2). To begin with, Hypothesis 1a is not supported. Instead, we found suggestive evidence in support of internal auditing occurring. All odds ratios of collaboration size are less than 1, regardless of statistical significance, indicating that collaboration size is negatively associated with the retraction event holding other factors constant. In other words, given that the diffusion of responsibility is more likely to occur under conditions of anonymity, we are happy to report that collaborative research does not necessarily mean to be dysfunctional.

Second, our data suggest that publications with authors from elite universities were less likely to be retracted. In the global dataset, 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 a global elite university. As shown in Global-Model 1 of Table 2, the odds-ratio for authors affiliated with a Top-100 university to withdraw a paper is 0.77. That is, holding other factors constant the odds of articles with at least one author from a Top-100 university being retracted were 23% lower compared with articles without a contributor from such a global elite university, which suggests a more pronounced premium of global elite universities in inhibiting flawed science. The same pattern also holds for collaboration size measured by number of institutional affiliations and number of countries. Moreover, if a paper enlisting an elite scientist had to be retracted, it was retracted quicker (see Global-Models 4–6 of Table 3).

One speculation for this phenomenon is that researchers, especially those at renowned universities, care more about their reputations and thus often assume rather than diffusing the responsibility of validating the collective product. Meanwhile, as collaboration involving leading scientists is likely to present research at the frontier, star-scientist-coauthored articles are more likely to draw attention from a larger community and to be scrutinized for the finding's validity so that flaw, if any, is also quicker to be detected. This result is different from those of Furman et al.'s (2012), which, controlling for first-year citations and authors affiliated with a Top-25 US university, concluded that neither retraction nor its quickness is correlated with the characteristics of the article, article's author, or author's institution.[12]

Also different from the findings of Furman et al.'s (2012), our study underscores that collaboration size measured by number of authors and number of affiliations has a statistically significant and positive impact on the speed of retraction. The logic is also simple, that is, a larger collaboration size means wider channels of knowledge diffusion and validation and therefore a higher probability of being identified for fraudulent findings or significant errors.

The third and final interesting finding concerns collaboration involving scientists from the countries of interests. As demonstrated in Tables 2 and 3, among the top five countries with the largest number of retractions, *ceteris paribus*, China and India stand out with the largest likelihood of retraction of the research involving their scientists as primary contributors, and China also is the very country with the fastest retracting speed. Indeed, such a phenomenon is typical among the emerging scientific powers whose goals of intimately linking scientific research to the national pride of catching up with and surpassing the incumbents may sometimes end up with unintended and mostly undesirable consequences (Segal, 2011).

We further zoomed in the Chinese case, which consists of 341 retractions and 629 corresponding matches. Opposite to the findings from the global dataset, China's internationally collaborated articles are more likely to be retracted compared to the work produced solely by its domestic researchers (China-Model 3 of Table 2).[13] The inhibiting role of elite authors on flawed research is even more substantially evident for Chinese

[12] Furman et al. (2012) confined elite universities to Top-25 or Top-50 US ones.

[13] This does not suggest that collaborative research between domestic Chinese scientists is less problematic but only means that the rate of spotted retractions is less for such research than the international collaboration involving scientists from China.

retractions: the odds of articles with at least one author from a Top-100 university being retracted were 52% (i.e. 1–0.48) lower than those of research without elite scientists. We also do not observe significant impact of collaboration size on the speed of retraction of Chinese articles. But as shown in China-Models 4–6 of Table 3, again, once China's flawed research was spotted, the involvement of authors from a global elite university speeded up retraction.[14]

6. Conclusion and Discussions

Drawing upon two different social psychological notions – diffusion of responsibility and internal auditing – on team effectiveness and applying them to retractions of collaborative research, we provide empirical evidence on the relationship between collaboration and retraction and the driving factors and the speed of retraction. Our findings especially contribute to the ongoing debate on factors impacting retraction at two fronts. First, given its importance as a driver for publication quantity and visibility, collaboration is worth studying in relation to retraction. In fact, to our knowledge, this is the first study coming up with evidence in support of the premium of team effect on deterring flawed research. Second, collaboration, especially involving elite scientists, seems to be more effective in helping spot then discourage, if not prevent, flawed research. Nevertheless, the rise of retractions, including those from collaboration involving scientists from elite institutions, also points to the existence of social loafing. There would have been less retractions had the flaw been detected in the stages of research, preparation of manuscripts for submission or internal checking.

As well as inspired by the prior scholarship (Azoulay et al., 2012; Furman et al., 2012; Lu et al., 2012; Jin et al., 2013), our research brings a new perspective – collaboration – into the literature on research retraction. We adopted the same nearest-neighbor-matching

[14] For robustness tests, we set a stringent criterion of any primary author from a Top-100 university involved in retraction (Please see Appendices 2 and 3), and similar patterns hold. Additionally, we also conducted the following robustness tests: Recode three collaboration size variables into dummy variables, i.e., single-authored paper vs. multi-authored paper, intra-organization collaboration vs. inter-organization collaboration; domestic paper vs. internationally collaborated paper; and added the squared terms of three collaboration size variables into the model. Such tests did not change the major findings. Results are available upon request.

approach (Furman et al., 2012) and tried to answer the same two questions raised in their work – factors correlating with the retraction event and factors correlating with the retraction time lag. While Furman et al. (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 not only extending the study of the retraction phenomenon to a much larger retracted group (2087 vs. 677) but also including a control group into the analysis. While Furman et al. (2012) controlled for Top-25 US universities, among others, 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. As such, in contrary to one of their major findings that retraction rate is "uncorrelated with article, author, or institution characteristics," we found that publications with authors from elite universities are less likely but quickly to be retracted.

Indeed, in addition to collaboration, other factors also may be associated with the likelihood and speed of retraction. But our methodological innovation – both the nearest-neighbor-matching approach and regression – allows us to control for such factors as research domain, publication year, journal visibility, research environment and culture. Although we are not seeing "direct" linkage between collaboration and retraction, our findings provide suggestive evidence to lend support that working together helps encourage responsible publishing behavior among researchers. As such, we are able to confidently conclude that even controlling for other compounding factors, on average, collaborated research is less likely to be "false science"; and that such "false science," once so labeled, is quicker to be retracted. Of course, the number/type of collaboration itself could be endogenous and driven by factors mentioned at the onset of the paper as well as others, such as easy access to facilities/resources, or validation of knowledge, or increased efficiency of knowledge production due to division of labor as noted in previous studies (Beaver and Rosen, 1979; Uzzi & Spiro, 2005). Given that this empirical study is based upon secondary data, we can only speculate explanations within our knowledge of research governance practice and extant literature.

Our interest in the relationship between collaboration and retraction is partly driven by the co-concurrence of increasing dominance of team science and rise of invalided knowledge. Therefore, our findings have policy implications for the governance of global science, especially that involves collaboration. To begin with, scientific misconduct is becoming a major horny problem that has bedeviled the research community for the last couple of decades. Therefore, globally, there is a compelling government interest in inhibiting false science. Our study suggests that jointly published research, especially with contributions of primary authors from top universities, is less likely to be retracted. This finding offers empirical support for policy proposals that endorse research collaboration, especially that with elite scientists at top universities.

Second and related, our findings are particularly relevant to current performance evaluation policy in some countries that highly de-incentivizes collaboration (Zhou, Thijs, & Glanzel, 2009; Yan, Rousseau, & Huang, 2015). Our analysis suggests that collaboration is positively correlated with the probability of reducing flawed research. China is now the second largest knowledge producer. Yet, in many Chinese universities only the status of first author or reprint author is counted toward faculty tenure and promotion (Tang, Shapira, & Youtie, 2015). For example, the written criteria for tenure and promotion at some institutions, such as Shanghai Jiaotong 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 excluded. Therefore, academics are understandably reluctant to collaborate if they are not listed as the primary authors, especially with competitors within the same college. This has suffocated internal collaboration (Wang et al., 2015).[15] If, however, Chinese universities change policies to give credits to all authorship toward tenure or to count all authorship equally, this would incentivize academics to collaborate. Of course, this may also 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.

[15] The concern is comparatively less as Chinese researchers do not compete against international partners for promotion and research funding. But still secondary authorship is highly undervalued for Chinese researchers in the situation of international collaboration.

Third, our empirical analysis demonstrates that publications with Chinese or Indian scientists as primary authors are far more likely to be retracted than those led by scientists from other major 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 have their seats at the league table of global academia (Zhou & Leydesdorff, 2007; *The Economist*, 2012; Liu, et al, 2013; Tang & Hu, 2013). 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 has severely damaged the reputation of not only their scientists but also their countries.

Fourth, notwithstanding unsupported evidence of diffusion of responsibility in publishing retractions, we appeal for authors and journal articles to explicitly state who has contributed and is responsible for which specific part of the research in the whole piece.

Before concluding, a few reminders on the caveats seem necessary. Retracted articles do not necessarily entail scientific misconduct; unintentional but significant errors can also lead to retraction. In this paper, we have not examined the *reasons* for paper retraction. It is conceivably fine for this particular analysis as, regardless of its heterogeneous causes, retracted articles are flawed research, or according to Azouley et al. (2012), “false science,” a shaky/unsteady stepping stone for later follow-on investigations (Mokyr 2002; Azouley et al., 2012).

References

Aggarwal, P., & O'Brien, C. L. (2008). Social loafing on group projects: Structural antecedents and effect on student satisfaction. *Journal of Marketing Education*, *30*(3), 255–264.

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.

Bonilla, J. Z. (2014). The nature of co-authorship: A note on recognition sharing and scientific argumentation. *Syntheses*, *1*, 97–108.

Cossette, P. (2004). Research integrity: An exploratory survey of administrative science faculties. *Journal of Business Ethics*, *49* (3), 213–234.

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.

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 of the United States of America*, *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.

Grieneisen, M. L., & Zhang, M. (2012). A comprehensive survey of retracted articles from the scholarly literature. *Plos One*, *7*(10), e44118.

Hailpern, S. M., & Visintainer, P. F. (2003). Odds ratios and logistic regression: further examples of their use and interpretation. *The Stata Journal*, *3*(3), 213–225.

Hummel, J., Huitt, W., Michael, R., & Walters, L. (1994). What you measure is what you get. *GaASCD Newsletter: The Reporter*, 10–11.

Jin, G., Jones, B., & Lu, S. F. (2013). The reverse Matthew Effect: Catastrophe and consequence in scientific teams. *NBER Working Paper*.

Johnson, D. W. (2003). Social interdependence: Interrelationships among theory, research, and practice. *American Psychologist*, *58*(11), 934.

LaFollette, M. C. (1992). *Stealing Into Print: Fraud, Plagiarism, and Misconduct in Scientific Publishing*. University of California Press, Berkeley and Los Angeles.

Liu, W., Gu, M., Hu, G., Li, C., Liao, H., Tang, Li., & Shapira, P. (2013). Profile of developments in biomass-based bioenergy research: A twenty-year perspective. *Scientometrics*, *99*(2), 507–521.

Lu, S. F., Jin, G. Z., Uzzi, B., & Jones, B. (2013). The retraction penalty: Evidence from the web of science. *Scientific Reports*, *3*, 1–5.

Macfarlane, B., Zhang, J., & Pun, A. (2014). Academic integrity: A review of the literature. *Studies in Higher Education, 39*(2), 339–358.

Naik, G. (2011), Mistakes in scientific studies surge. *The Wall Street Journal*, August 10.

Melin, G., & Persson, O. (1996). Studying research collaboration using co-authorships. *Scientometrics*, *36*(3), 363–377.

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*. National Academies Press, Washington, DC. http://sites.nationalacademies.org/dbasse/bbcss/currentprojects/dbasse_080231 (accessed January 14, 2016).

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), 3–8.

Pozzi, A., & David, P. (2007). *Empirical Realities of Scientific Misconduct in Publicly Funded Research*. Working paper, Stanford University.

Redman, B. K., Yarandi, H. N., & Merz, J. F. (2008). Empirical developments in retraction. *Journal of Medical Ethics, 34*(11), 807–809.

Riederer, B. M. (2014). Scientific misconduct and ethical aspects in publishing. *Laboratory Animals*, *48*(3), 272.

Royal Society (2011). *Knowledge, Networks and Nations: Global Scientific Collaboration in* *the 21st Century.* The Royal Society, London.

Segal, A. (2011). *Advantage: How American Innovation Can Overcome the Asian Challenge*. W. W. Norton & Company, New York.

Sheth, B. P., & Thaker, V. S. (2014). Scientific retraction: A synonym for pseudoscience? *ActaBioethica*, *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.

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*, 1–10. DOI: 10.7554/eLife.02956.

Tang, L., Shapira, P., & Youtie, J. (2015). Is there a clubbing effect underlying Chinese research citation increases? *Journal of the Association for Information Science and Technology*, *66*(9), 1923–1932.

Tang, L. & Hu, Guangyuan. (2013). Tracing the footprint of knowledge spillover: Evidence from U.S.-China collaboration in nanotechnology. *Journal of the American Society for Information Science and Technology*, *64*(9), 1791–1801.

Teng, C.-C., & Luo, Y.-P. (2015). Effects of perceived social loafing, social interdependence, and group affective tone on students' group learning performance. *Asia-Pacific Education Researcher*, *24*(1), 259–269.

Tsai, W. C., & Chi, N. W. (2008). Exploring antecedents, boundaries, and individual-level consequences of group affective tone. *Organization and Management*, *1*(1), 1–37.

Uzzi, B., & Spiro, J. (2005). Collaboration and creativity: The small world problem. *American Journal of Sociology*, *111*(2), 447–504.

Wang, J., & Hicks, D. (2015). Scientific teams: Self-assembly, fluidness, and interdependence. *Journal of Informetrics*, *9*(1), 197–207.

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.

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.

Xue, L. (2008). China: The prizes and pitfalls of progress. *Nature*, *454*(7203), 398–401.

Yan, S., Rousseau, R., & Huang, S. (2015). Contributions of Chinese authors in PLOS ONE. *Journal of the Association for Information Science and Technology*. Forthcoming. Article first published online on 12 March 2015. DOI: 10.1002/asi.23400.

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.

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., & Leydesdorff, L. (2006). The emergence of China as a leading nation in science. *Research Policy*, *35*, 83–104.

Zhou, P., Thijs, B., & Glanzel, W. (2009). Is China also becoming a giant in social sciences? *Scientometrics*, *79*(3), 593–621.

Zuckerman, H. (1988). The sociology of science. In *Handbook of Sociology*, ed. Neil J. Smelser, 511–574. Sage, Newbury Park, CA.

Retraction: The Other Face of Research Collaboration

Figures and Tables

Figure 1 Distribution of Journal Impact Factors of Retracted Articles by Quartile

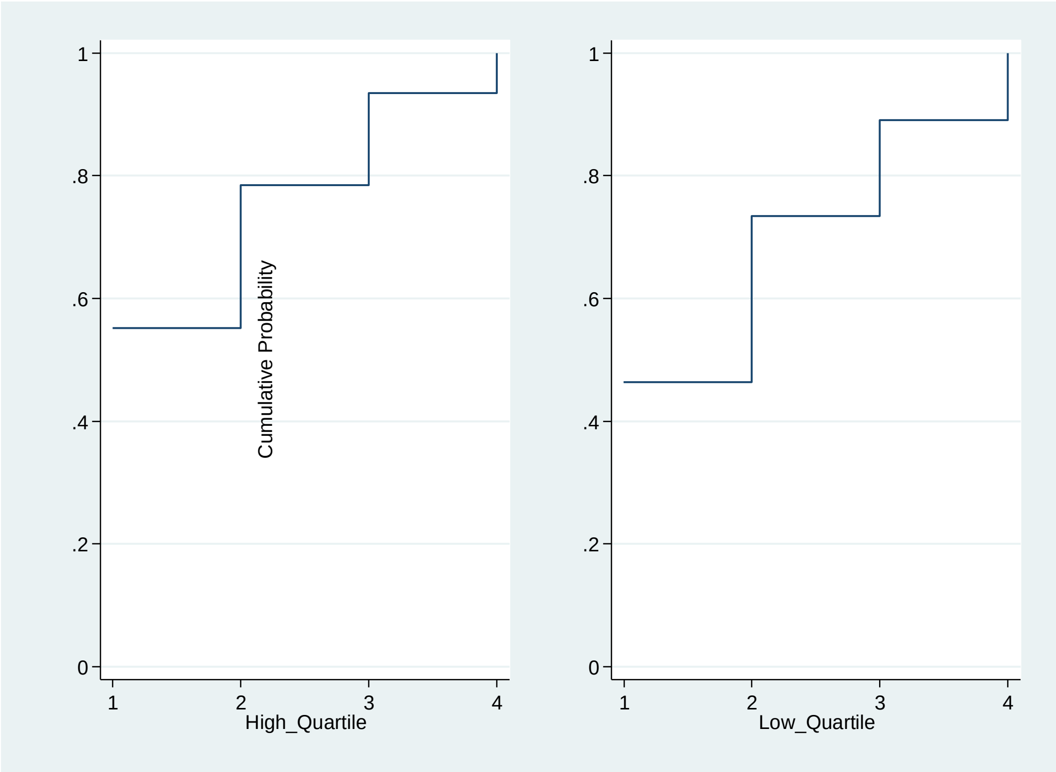
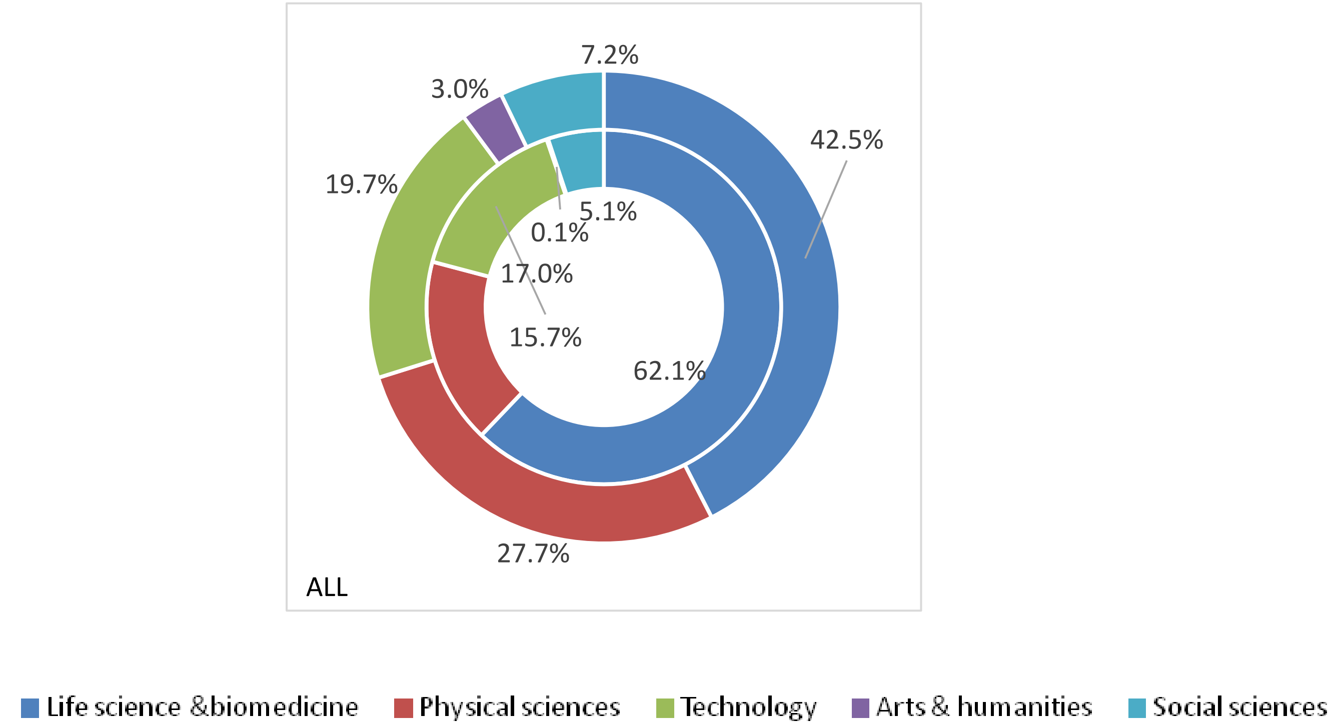
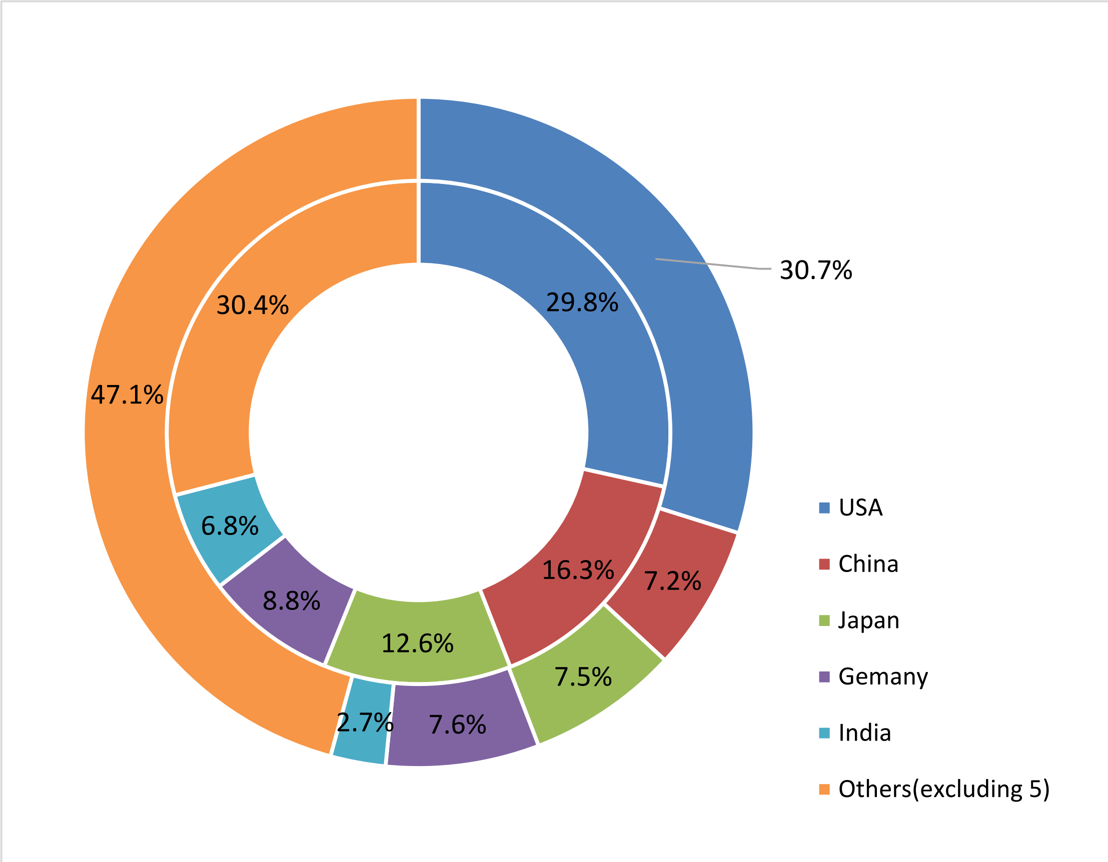


Figure 2. Article distribution by WoS research areas: Retractions vs All WoS articles



Note: Records retrieved and calculated by authors. The number and proportion of WoS articles in different research areas were retrieved and analyzed online on June 18, 2016.

Figure 3. Article distribution by countries: Retractions vs All WoS articles



Note: Records retrieved and calculated by authors. The number and proportion of WoS articles in countries were retrieved and analyzed online on June 18, 2016.

Figure 4. Box plots of collaboration size and time to retraction: China vs. Global

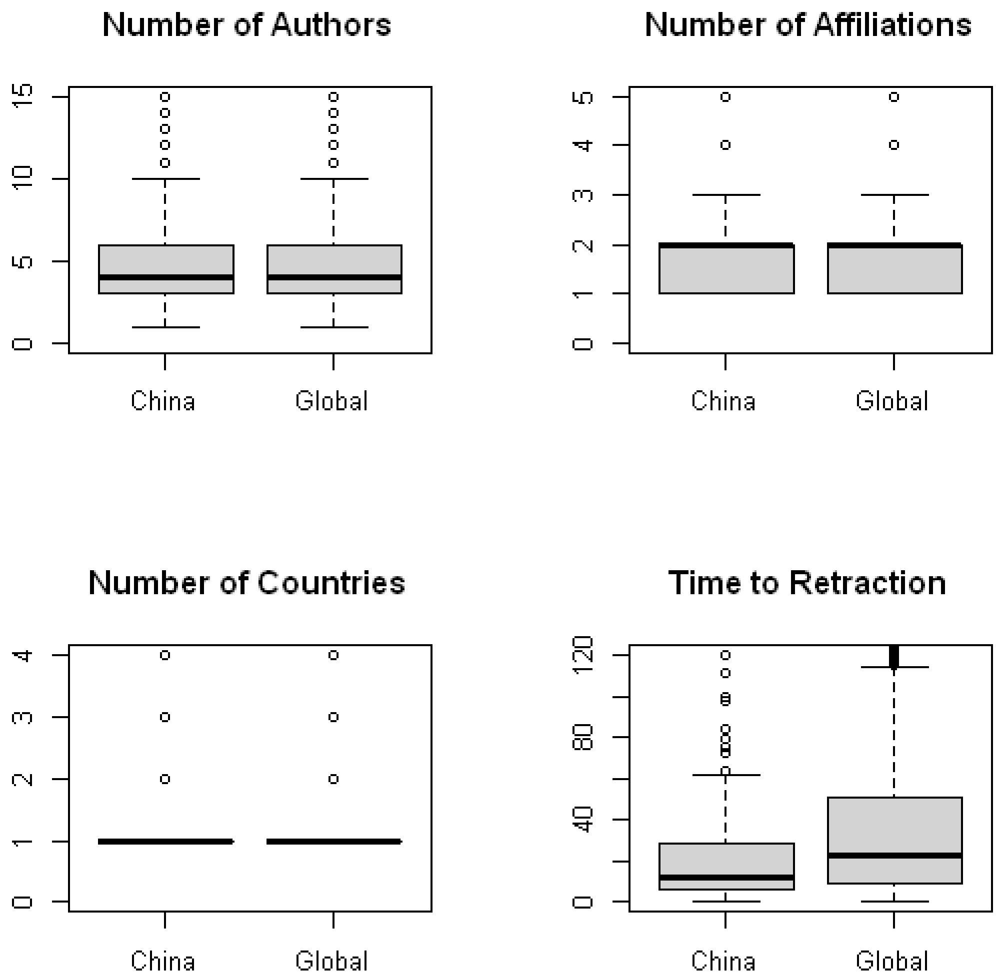


Table 1 Details of collaboration size and time to retraction between retracted and control groups

	Number of Authors				Number of Affiliations			
	Min	Mean	Median	Max	Min	Mean	Median	Max
Retracted	1	4.95	4	32	1	1.92	2	16
Control	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
Retracted	1	1.24	1	8	0.00	39.14	23.00	325.00
Control	1	1.29	1	12	N/A	N/A	N/A	N/A

Table 2 Logistic regressions on retractions and matched records: 1978–2013

	Panel 1: Odds Ratio [95% Conf. Interval]			Panel 2: Odds Ratio [95% Conf. Interval]		
	Global-Model 1	**Global-Model 2**	**Global-Model 3**	**China-Model 1**	**China-Model 2**	**China-Model 3**
Number of Authors	0.95 [0.94-0.97]***			0.97[0.92-1.02]		
Number of Affiliations		0.92[0.88-0.96]***			0.92[0.82-1.03]	
Number of Countries			0.95[0.87-1.04]			1.24[0.99-1.56]*
Top 100 Univ.	0.77[0.67-0.88]***	0.78[0.68-0.90]***	0.75[0. 65-0.86]***	0.48[0.30-0.75] ***	0.49[0.31-0.77]***	0.43[0.27-0.69]***
PrimaryAuthor USA	1.12[0.97-1.30]	1.11[0.96-1.28]	1.12[0.97-1.30]	/	/	/
PrimaryAuthor China	**2.19[1.82-2.62] *** **	**2.08[1.74-2.50] *** **	**2.10[1.75-2.52] *** **	/	/	/
PrimaryAuthor Japan	1.92[1.59-2.33] ***	1.84[1.52-2.22] ***	1.82[1.50-2.20] ***	/	/	/
PrimaryAuthor Germany	1.66[1.32-2.10] ***	1.62[1.29-2.05] ***	1.64[1.30-2.06] ***	/	/	/
PrimaryAuthor India	**2.97[2.27-3.87] *** **	**2.94[2.25-3.84] *** **	**3.01[2.31-3.93] *** **	/	/	/
Control for Publication Year	Yes	Yes	Yes	Yes	Yes	Yes
Control for Research Area	Yes	Yes	Yes	Yes	Yes	Yes
Control for Journal impact factor	Yes	Yes	Yes	Yes	Yes	Yes
N	6054	6054	6054	970	970	970
Pro>chi^2	0.0000	0.0000	0.0096	0.0669	0.0516	0.0309
Pseudo R^2	0.03	0.03	0.02	0.01	0.01	0.01

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

Table 3 OLS regressions on log(time-to-retraction): 1978–2013

	Panel 3: Coef. (Std. Err.)			Panel 4: Coef. (Std. Err.)		
	Global-Model 4	**Global-Model 5**	**Global-Model 6**	**China-Model 4**	**China-Model 5**	**China-Model 6**
Number of Authors	0.02 (0.01)**			0.02 (0.01)		
Number of Affiliations		0.03 (0.02)*			0.07(0.05)	
Number of Countries			0.04 (0.04)			0.02(0.10)
Top-100 Univ.	-0.13 (0.05)**	-0.13 (0.05)**	-0.12(0.15)*	-0.40(0.16)**	-0.45(0.17)***	-0.39(0.19) **
PrimaryAuthor USA	0.05 (0.06)	0.06 (0.06)	0.05 (0.06)	/	/	/
PrimaryAuthor China	**-0.11(0.06)***	**-0.10(0.06)**	**-0.10(0.06)**	/	/	/
PrimaryAuthor Japan	0.64(0.07)***	0.66(0.07)***	0.66(0.07)***	/	/	/
PrimaryAuthor Germany	0.36(0.08)***	0.37(0.08)***	0.37(0.08)***	/	/	/
PrimaryAuthor India	0.17(0.08)**	0.17(0.08)**	0.17(0.08)**	/	/	/
Control for Year	Yes	Yes	Yes	Yes	Yes	Yes
Control for Research area	Yes	Yes	Yes	Yes	Yes	Yes
Control for Journal impact factor	Yes	Yes	Yes	Yes	Yes	Yes
N	2086	2086	2086	341	341	341
Pro>F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R^2	0.35	0.35	0.35	0.30	0.30	0.29

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

For robustness testing, we also test if the first author or the corresponding author is affiliated with any of the Top-100 or Top-50 research universities. The results are similar.

Appendix 1 Summaries of major empirical studies on retractions

Literature	Data source	Year coverage	Num. of Retractions	Main findings	Main challenges	Notes
Azoulay et al. (2012)	PubMed	Retracted articles published prior to 2007	1,104	Retractions "cause a relative decline in the vitality of neighboring intellectual fields."	Delineate the boundaries of the research fields affected by retracted articles; confined to biomedical research.	It suggests the existence of negative spillover effect of citation penalty surrounding intellectual fields of retracted articles.
Lu et al. (2013)	WOS	2000–2011	1,423	Citation penalty for non-self-reporting retraction goes beyond the retracted paper itself.	Name ambiguity: correctly cluster papers contributed by the same author. Name and low matching rate: around two third matched.	"Self-reporting mistakes is (sic) associated with no citation penalty and possibly positive citation benefits among prior work."
Jin et al. (2013)	WOS	1993–2011	667 single retractions	Reverse Matthew Effect, i.e. "scientific misconduct imposes little citation penalty on eminent coauthors."	Name disambiguation is a big challenge, which the authors did not discuss in their manuscript.	"These findings suggest that a good reputation can have protective properties, but at the expense of those with less established reputations."

Furman et al. (2012)	PubMed	1972–2006	677 retracted articles	Retracted articles arise most frequently In highly-cited research, yet retraction is not systematically impacted by author prominence; Retraction penalty on citations is not immediate, but also severe and long lasting.	Using the Top-25 US universities as a proxy indicator of author prominence.	They found no observable factors impact time to retraction except for publication year.
Wager & Williams (2011)	Medline	2005–2008	312	Reasons for retraction vary.	Biomedical journals are examined.	"Analysis of the retractions on Medline suggests that journals' retraction practices are not uniform."
Fang et al. (2012)	PubMed	Prior to 2012	2047	The majority of retractions are caused by misconduct; retractions exhibit distinctive temporal and geographic patterns.	Confined to biomedical and life-sciences research.	Actual number of fraudulent articles cannot fully captured by retraction notices; alternative sources of information should be utilized in order to fully and correctly categorize retraction causes.

Grieneisen & Zhang (2012)	42 data sources		4,449	Repeat retractors are globally distributed and skew distribution at country and institutional levels.	Compatible and comparable feature (such as citation measurement) of retracted articles indexed in different databases.	Calling for more active roles of publishers, bibliographic databases, and research software tools to help researchers stay from shaking shoulders of science.
Steen (2011a)	PubMed	2000–2010	742 English papers	About three quarters of retracted articles are due to error or undisclosed reasons	Only use retraction notice to categorize retraction reasons.	It remains unclear what and how role bias plays in retraction.
Steen (2011b)	PubMed	2000–2010	788 English papers	Retractions are clustered instead of randomly distributed in scientific research.	Only use retraction notice to categorize retraction reasons.	How to characterizing deliberately fraudulent authors would be an interesting topic worthy of further exploration.

This paper (2016)	WoS	1978–2013	2087	No significant evidence indicates that collaboration suffers for producing flawed research. Ceteris paribus publications with authors from elite universities are less likely but quickly to be retracted. Country characteristics in retractions also explored.	Similar to some of the previous studies, retracted articles could be the tip of iceberg of the flawed research.	Policy implications for the enhancement of the governance of knowledge production in collaborative research.

Appendix 2 Robustness tests on Hypothesis 1

	Global Data: Odds Ratio [95% Conf. Interval]			China Data: Odds Ratio [95% Conf. Interval]		
	Global-Model7	**Global-Model 8**	**Global Model 9**	**China-Model 7**	**China-Model 8**	**China-Model 9**
Number of Authors	0.95 [0.93-0.97]***			0.96[0.91-1.01]		
Number of Affiliations		0.90[0.878-0.94]***			0.88[0.79-0.99]**	
Number of Countries			0.92[0.84-1.00]*			1.12[0.90-1.40]*
Primary top100 Univ.	0.72[0.61-0.84]***	0.72[0.62-0.85]***	0.73[0. 62-0.85]***	0.24[0.12-0.47] ***	0.24[0.12-0.46]***	0.25[0.13-0.48]***
PrimaryAuthor USA	1.14[0.98-1.31]*	1.12[0.97-1.30]	1.12[0.97-1.30]	/	/	/
PrimaryAuthor China	**2.20[1.84-2.64] ***	**2.08[1.74-2.49] ***	**2.11[1.76-2.52] ***	/	/	/
PrimaryAuthor Japan	1.92[1.58-2.32] ***	1.82[1.51-2.20] ***	1.79 [1.48-2.16] ***	/	/	/
PrimaryAuthor Germany	1.67[1.33-2.11] ***	1.63[1.29-2.05] ***	1.64[1.31-2.07] ***	/	/	/
PrimaryAuthor India	**2.99[2.29-3.90] ***	**2.94[2.25-3.84] ***	**3.03[2.32-3.96] ***	/	/	/
Control for Publication Year	Yes	Yes	Yes	Yes	Yes	Yes
Control for Research Area	Yes	Yes	Yes	Yes	Yes	Yes
Control for Journal impact factor	Yes	Yes	Yes	Yes	Yes	Yes
N	6054	6054	6054	970	970	970
Pro>chi^2	0.0000	0.0000	0.0096	0.0010	0.0003	0.0015
Pseudo R^2	0.03	0.03	0.02	0.02	0.02	0.02

Appendix 3 Robustness tests on Hypothesis 2

	Global retraction data: Coef. (Std. Err.)			China retraction data: Coef. (Std. Err.)		
	Global-Model 10	**Global-Model 11**	**Global-Model 12**	**China-Model 10**	**China-Model 11**	**China-Model 12**
Number of Authors	0.01 (0.01)**			0.02 (0.02)		
Number of Affiliations		0.02 (0.02)			0.03(0.05)	
Number of Countries			0.02 (0.04)			-0.08(0.10)
Primary Top-100 Univ.	-0.11 (0.06)**	-0.11 (0.06)*	-0.10 (0.16)*	-0.31(0.27)	-0.30(0.27)	-0.21(0.28)
PrimaryAuthor USA	0.05 (0.06)	0.05 (0.06)	0.05 (0.06)	/	/	/
PrimaryAuthor China	**-0.11(0.06)***	**-0.10(0.06)**	**-0.10(0.06)**	/	/	/
PrimaryAuthor Japan	0.64(0.07)***	0.66(0.07)***	0.66(0.07)***	/	/	/
PrimaryAuthor Germany	0.36(0.08)***	0.38(0.08)***	0.37(0.08)***	/	/	/
PrimaryAuthor India	0.17(0.08)**	0.18(0.09)**	0.17(0.08)**	/	/	/
Control for Year	Yes	Yes	Yes	Yes	Yes	Yes
Control for Research area	Yes	Yes	Yes	Yes	Yes	Yes
Control for Journal impact factor	Yes	Yes	Yes	Yes	Yes	Yes
N	2086	2086	2086	341	341	341
Pro>F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R^2	0.35	0.35	0.35	0.29	0.29	0.29