Standing on Slippery Shoulders. An Analysis of post-Retraction Citation in Business and Management.

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Abstract

The recognition mechanism by citing those who have influenced a new piece of research is considered the best way to guarantee scientific progress. The metaphor used by Sir Isaac Newton, "standing on the shoulders of giants," illustrate this mechanism. However, the increasing number of retractions and citations they receive reveal that, in some cases, scientists are standing on "slippery shoulders." Hence, it is relevant to explore the phenomena of post-retraction citations. Our study focuses on three research questions: i) time to retraction, ii) citations received by retracted papers, and iii) highly influential citations received the retractions. We answer these questions using a data set from Retraction Watch comprising 949 retractions in three Areas (Business & Management, Social Sciences, and Technology). First, we conduct an ANOVA analysis to find significant differences among the three areas. Later, we estimate three Poisson models to answer the three research questions. We discovered that retractions in Business & Management are published in more prestigious journals and by more prominent institutions than in the other two areas. From the models, we highlight that the journals' prestige positively affects the time to retraction, the post-retraction citations, and, more worryingly, the highly influential citations. Our results suggest that scientists seem to be unaware that some papers have been retracted. We suggest journals improve the procedure to prevent publishing papers citing retracted papers.

Keywords. Retraction, Misconduct, Business & Management.

Acknowledgments: We thank Dr. Ivan Oransky from the Center for Scientific Integrity for allowing us to use the Retraction Watch database.

1. Introduction

Scientific misconduct is an increasing concern among the leading academic stakeholders (Armond et al. (2021), Hall & Martin (2019), Marcus & Oransky (2014)). Academic journals use retractions – published articles withdrawn by authors, employers, editors, or publishers – with a twofold aim: to punish the scholars who use questionable research practices and to purge the effect of the so-called "false science" results (i.e., erroneous or unethical research) on subsequent research. Recent studies have shown that the number of retracted articles is growing faster than the total number of scientific publications (Cokol et al., 2008; Marcus and Oransky, 2014). Alarmingly, retracted papers continue to be cited by scientists who do not figure out -or even do not care- the articles they are citing are flawed. Indeed, most of the citations to retracted papers are positive, even if the reason for retraction was scientific fraud (Bar-Ilan and Halevi, 2017).

Our study focuses on citations to retracted papers in the fields of Business and Management. To the best of our knowledge, there are no previous similar studies. We first consider the main characteristics of citations to retracted papers and, second, investigate the determinants of these citations. We conducted the study with a data set of retracted papers from the Center for Scientific Integrity's Retraction Watch Database-henceforth RWDB-. This database categorizes all the documents into different areas. We filtered the records only to include research articles, retracted articles, or review articles (a subset of the entry types in RWDB) *published* before 2021 of the "Business/Technology (B/T)" area, and those that had a DOI as well. This left 1,445 valid cases from the original 27,439 we had access to. Next, we classified all the selected documents into three main areas: i) Business and Management, ii) Social Sciences, and iii) Technology. From RWDB, we set information regarding the type of misconduct, date

of retraction, number of authors, affiliation, etc. Next, we completed the data from RWDB with information about citations and the journal's prestige from Scopus and highly influential citations from Semantic Scholar (Lo et al., 2020). Finally, we added an indicator for the institution's prestige from the CWUR (Centre for World University Rankings). We only got complete information for a set of 949 cases. We conducted two types of analysis. First, we compared the main variables among the three research fields. Second, we estimated three multivariable models to explore the determinants of three variables: i) time to retraction, ii) post-retraction citations, and iii) post-retraction highly influential citations.

We found statistically significant differences among the three main areas. For example, the retractions in Business and Management are due to more severe misconducts, and they are also retracted after a more extended period than in Social Sciences and Technology. Besides, the journals and institution prestige are higher in Business and Management papers. In addition, and probably due to the reported differences, retractions in Business and Management also receive more highly influential citations before the retraction. The regression analysis highlights the journal's prestige role in explaining the total and the highly influential citations after the retraction. That could mean that some scientists are unaware that the papers they cited are retracted and continue citing them.

We make three contributions to this piece of research. First, we show the figures related to post-retraction citation practices in the field of Business and Management. Second, we used the classification provided by Semantic Scholar to enrich the analysis, considering the highly influential citations perceived by retracted papers. This result

shows to which extent the metaphor “standing on the shoulders of giants” should be replaced by “standing on slippery shoulders.” Last, we use regression analysis to identify the determinants of three critical variables: time to retraction, post-retraction citations, and post-retraction highly influential citations.

The remainder of this paper is organized as follows. Section 2 describes the literature on post-retraction citation studies, and we state some research questions. Section 3 describes our research setting, including the three models' specification. In section 4, we report the results. We conclude with a discussion and outline further research in section 5.

2. Background and Motivation.

Our study aims to analyze the so-called post-retraction citations in the fields of Business and Management. Since retractions are due to different reasons, before establishing the study framework, we need a criterion to classify retractions. Later, we will summarize the specialized literature's main findings associated with retractions. Finally, we pose research questions after reporting the main findings regarding post-retraction citations.

Regarding the type of retractions, there is a wide diversity of criteria. For example, Bar-Ilan and Halevi (2018) establish three main groups: ethical misconduct, scientific distortion, and administrative errors. A different approach is used by Azoulay et al. (2015), categorizing the retraction events into three sets of “buckets”: i) Strong shoulders (retractions that do not invalidate the results), ii) Shaky shoulders (parts of the results are invalid), and iii) Absent shoulders (retractions with fraudulent results). Feng et al., in 2020, considered two major categories of retraction reasons: misconduct and scientific

errors, which can be combined between them given four types: academic misconduct and error, academic misconduct and no errors, no academic misconduct and no errors, and no academic misconduct and errors (Feng et al., 2020). In this study, we have classified all the reasons for retractions based on the misconduct taxonomy developed by Hall and Martin (2019), which identifies four levels of severity: appropriate conduct, questionable conduct, inappropriate conduct, and blatant misconduct.

Having established the typology of retractions we use in this study, we explore the main variables associated with retractions in the specialized literature. The first factor we consider is the **number of authors**. When studying the factors which can affect the retractions, the team size is evaluated by several articles, such as (Sharma 2021). This study reveals that the smaller the team size, the lower the number of retractions. Other studies examined the **affiliation's countries** as a factor in explaining retractions. Halevi and Bar-Ilan (2020) found that most of the retracted articles come from the USA, China, India, and Japan for a set of retracted papers in Medical Sciences published between 2010 and 2014 and retracted before 2017. A similar result was found by Sharma (2021), studying a group of retractions from many disciplines from 1981-2020. They found that most retracted articles come from China, followed by the USA, India, and Japan. Other analyses combined countries with the reasons for retraction. For example, Fang et al. (2012) found an association between the geographic origin and the reason for retraction: When it comes to fraud or suspected fraud, the USA is the first one, followed by Germany and Japan; for plagiarism, the USA is followed by Japan and China and, finally, referring to duplicate publication, the USA, Germany, and Japan (Fang et al., 2012).

Another frequently analysed factor is the **journal prestige**. Fang et al. (2012) found a positive correlation between the journal impact factor and the number of retractions for fraud or suspected fraud. They identified a slight correlation with the number of retractions for plagiarism or duplicated publication. However, it seems there is a lack of consensus regarding this variable. Sharma (2021) studied 12,231 research papers indexed by the Web of Science as retracted from 1980 to 2020. He did not find a significant relationship between the journal impact factor and the number of retractions. Considering a sample of open-access journals, Wang et al. found that most retractions occur in journals with a low impact factor (Wang et al., 2019). In the field of Economics, Cox et al. (2018), found that most retractions take place in journals with a low impact factor.

Some studies have explored the relationship between the number of retracted papers and the **Institution prestige**. These studies mainly conclude that institutions' prestige is positively related to retractions. However, this relationship can be influenced by the higher volume of publications, the pressure to publish, and the high payoffs for publication in prestigious journals (Mohan, 2019). These conditions may induce scholars to engage in ethically questionable research habits (Fang et al., 2012). Azoulay et al. (2017) state that publishing has become a crucial means, "a game of hit and miss," to improve academic careers and achieve institutional prestige. Indeed, academic institutions' prestige is rated according to the frequency of their faculty publications. The research carried out by Pfleegor et al. (2019) spotlighted another critical factor related to prestige: pressure to be a productive academic. The urge to publish a high volume of works (to increase the author's and institution's prestige) becomes a negative incentive to use unethical practices. In the specific case of business schools, Honig et al. (2014)

identified the increasing competition for prestige and visibility between institutions as the driving force for publication and unscrupulous research methods. Other authors have found different connections between prestige and unethical research practices. Furman et al. (2012) have shown that papers with a noticeable number of citations (which undoubtedly affects the prestige of the author and the publishing institution) but "false science" experience a considerable time difference between the publication and the retraction date. The fact that the necessary retraction is undetected improves the author's prestige (because of the many citations) before the paper is retracted. Gift authorship is another questionable practice that positively correlates prestige with retractions. Prestigious researchers are co-authors, even if not actively involved in the work. This inappropriate behaviour, usually impossible to detect even if affecting the integrity and honesty of the paper, enhances the prestige of the average authors as they appear to have worked with reputable authors. In general, previous researchers have identified that in many cases, prestige is the goal of authors, who may undertake unethical research practices and behaviours to achieve said prestige and visibility.

To conclude this section, we focus on post-retraction citations which open some interesting insights to be explored. For example, to which extent retracted papers are cited, or whether these citations are positive or negative. Hsiao and Schneider (2022) studied this topic for a sample of retractions in Biomedicine. They found that retracted publications continued to be cited after retraction. This study is also aligned with others, such as (Halevi & Bar-Ilan, 2020) where they examine medical and biomedical retracted papers using the RWDB Database and, among other characteristics, they find that the average number of years to retract from 2010 to 2014 is between 1 and 3, observing that the number of years goes down from 2.67 in 2010 to 1.07 in 2014. This decrease over

time could be due to technological development and increased post-publication interaction (Bar-Ilan & Halevi, 2018). In economics, Cox, Craig, and Tourish (2018), found that the majority (64%) of the retracted publications studied (n=55) were retracted within a year of publication (Cox et al., 2018). Bolland et al. (2022) have expressed their concerns about the huge number of citations of retraction papers that make no mention at all to the retraction itself. They express the need to assess the impact that the citation of retracted papers might have on the results and conclusions of the publications. In a study carried out by Candal-Pedreira et al. (2020) where they analyse the number of citations before and after the retraction of 304 retracted papers, published from 2013 to 2015 and retracted from 2014 to 2016, in the field of biomedical sciences, and considering the journal impact factor (divided into quartiles), they found that retracted articles continue to be cited in the long term. When comparing by quartiles, only the citations of retracted articles published in journals of the first quartile show a reduction after retraction.

Besides the number of citations, it is interesting to explore the type of citations. For example, Bar-Ilan et al. (2017) explored whether the citations can be considered positive, neutral, or negative. They found that most of the citations are positive, which implies the retracted article was cited to validate the retracted paper and, more worryingly, to confirm that its findings corroborate the citing study.

In this paper, we use the citation classification provided by Semantic Scholar, which identifies several types of citations by using an AI algorithm. Notably, the so-called highly influential citations that are particularly relevant to diagnose to which extent retracted papers are still considered relevant research. Once we have reviewed both the

characteristics and the determinants of post-retraction citations, we can posit the following research questions:

RQ1: ***What are the main characteristics of retracted papers in Business and Management compared to papers from other areas?***

RQ 2: ***What is the post-retraction citation pattern in Business and Management?***

RQ 3: ***What are the main determinants of post-retraction citations in Business and Management?***

3. Data and Methods.

3.1. Database.

Our database comprises variables that come from four different sources: i) RWDB, ii) Scopus, iii) Semantic Scholar, and iv) Centre for World University Rankings (CWUR). We were given data from the RWDB database from its temporal origin ("the first retraction") until the 14th of June 2021. The records were filtered to only include research articles, retracted articles, or review articles (a subset of the entry types present in RWDB) published before 2021 of the "Business/Technology (B/T)" area (a categorization done by RWDB), and those that had a DOI as well. This left 1,445 valid cases from the original 27,439 we had access to.

We used the articles' DOI to query Scopus information to be added to our records. The information recovered from Scopus may be divided into two areas: information about the publication (authors, title, year of publication, affiliations, funding details, publisher)

and the citation history (citations per year between 2005 and 2020), both counting self-citations and omitting them. Additionally, some journal indicators were collected from the SCOPUS CiteScore 2011-2020 file, which was downloaded and merged with the other information mentioned above to provide information about the publications in which the retracted papers were initially published. Notably, we have taken note of the SNIP (source normalized impact per paper) (Moed, 2016). SNIP enables direct comparison of sources in different subject fields. Regarding Semantic Scholar, we gathered information about Highly Influential Citations, Background Citations, Methods Citations, and Results Citations retrieved from Semantic Scholar for every paper for which such information was available. Finally, the other two variables were gathered from the CWUR. For every institution involved in the retracted articles, its CWUR score was retrieved. For each article, we selected the maximum score (i.e., the most prestigious institution) of all the institutions involved in each paper. With the collected information, we elaborated a set of indicators appropriate for this analysis that we describe below (See Table 1).

Using the retraction date, the aggregate number of citations before retraction and after retraction was obtained. Cases for which the retraction date was not between 2005 and 2020 were discarded. The number of elements was counted for each variable that may include more than one, and those aggregates were added as columns (number of authors, countries, etc.).

Based on the taxonomy established by Hall and Martin (2019), we have taken the reasons for retraction given by RWDB, and we have classified them into two groups: First, according to the nature of behaviour we identify five categories: (i) data

manipulation, (ii) Use of work by others, (iii) Use of own work, (iv) Authorship; (iv) Materials and methods manipulation. The later one is added to the Hall and Martin taxonomy. Second, according to the degree of misconduct, we classify the retractions in four categories: (i) Appropriate Conduct; (ii) Questionable Conduct; (iii) Inappropriate Conduct; and (iv) Blatant misconduct.

The inexistence of a comprehensive test or methodology for classification led us to refer to the examples provided in the original taxonomy for guidance in an otherwise fully subjective classification[1]. The multiplicity of reasons that many of the retracted articles (severely increasing the cardinality of the data) had led us to creating a methodology which could simplify that information into, ideally, an individual measure. We call this the *Maximum Blame* criterion according to which the articles with one stated reason stay with that reason, and the articles which have more than one reason, we select the reasons with highest degree of misconduct. If there is one or they all belong to the same nature, then that combination is preserved; otherwise, we will have to preserve as many unique nature-maximum degree pairs as there are. While this criterion could be considered indecisive for the most complex case, we prioritized preserving information. Any extension that would provide an "amount of blame" would be an exercise of discretion for which we have no authority.

Finally, from Semantic Scholar, we gathered the number of Highly Influential Citations (HIC) for each retracted paper. According to the Semantic Scholar's web, the number of citations for each publication is counted based on the automatic identification

[1] We recommend that the scientific community should come up with a unified and codified set of rules regarding misconduct borrowing from existing customs – on its own or through standardization organizations.

of papers that cite or mention the publication. Although this identification covers all the data available in their "corpus", the primary focus is published academic articles and preprints, while books are limitedly covered, and patents are not included. Although not fully accurate (due to the above-mentioned limitations), Semantic Scholar represents a trustworthy and reliable site for knowing about the citations of primarily any publication.

3.2. Variables

The lack of consensus on the determinants of post-retraction citations makes it impossible to set empirical hypotheses. Hence, we focus on answering the three research questions stated in Section 2. To do so, we have defined and measured the set of variables that we describe below.

- AREA is a categorical variable that classifies all the papers included into three main areas: Business and Management, Social Sciences, and Technology[2].
- Misconduct is an ordinal variable that represents the four degrees of misconduct above mentioned.
- TIME is the number of days between paper publication and its retraction.
- TEAM is the number of authors of each retracted paper.
- SNIP measures the journals' prestige allowing comparisons among areas.
- Department is the maximum score of all the institutions where the authors of each retracted paper are affiliated.
- CIT_PRE represents the number of citations received before the retraction divided by the number of years between publication and retraction.

[2] Business and Management comprises the RWDB fields of Accounting, Business, Management, Manufacturing, and Marketing). Social Sciences includes Economics, Foreign Aid, International Relations, Government, Public Relations, Transportation, and Urban Planning. Technology comprises Technology and Computer Science.

- CIT_POST represents the number of citations received after the retraction divided by the number of years between retraction and 2021.
- HIC_PRE represents the number of highly influential citations received before the retraction divided by the number of years between publication and retraction.
- HIC_POST represents the number of highly influential citations received after the retraction divided by the number of years between retraction and 2021.

Table 1 summarizes the definition and sources of all the variables considered in this study.

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Insert Table 1 about here

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3.2 Methodology

First, we have conducted a comparative analysis to explore the main differences among the three main areas described above (i.e.: Business and Management, Social Sciences, and Technology) with respect to a set of variables. Second, we estimate some models to explore the determinants of the following variables: time to retraction (Days), Citation rate post-retraction (CIT_POST), and Highly Influential citation rate after retraction (HIC_POST). All the estimations have been carried out with STATA 15 using robust estimation methods. We used Poisson regression models since the dependent variables are integer numbers or ratios.

Model 1 explains the time to retraction in terms of the misconduct level, the team size, the journal and department prestige, the days until retraction, and the citation rate before retraction. The specification of the time to retraction reads as follows:

$$\text{Log(Days)} = a_1 + a_2\, Misconduct + a_3\, TEAM + a_4\, SNIP + a_5 Department + a_6\, CIT\ PRE + a_7\, SocialScience + a_8\, Technology + \varepsilon \quad [1]$$

Model 2 estimates the citation rate post-retraction in terms of the time to retraction and the same set of variables as the previous specification. We consider the following specification:

$$Log(CIT\ POST) = b_1 + b_2 TIME + b_3\, Misconduct + b_4\, TEAM + b_5\, SNIP + b_6 Department + b_7\, CIT\ PRE + b_8\, SocialScience + b_9\, Technology + \varepsilon \quad [2]$$

Lastly, Model 3 estimates the effect on highly influential citation rate post-retraction in terms of the highly influential citation rate pre-retraction and the citation rate post-retraction and the same set of variables as the previous specification. The third model specification reads as follows:

$$Log(HIC\ POST) = c_1 + c_2 CIT\ POST + c_3\, HIC\ POST + c_4\, TIME + c_5\, Misconduct + c_6\, TEAM + c_7\, SNIP + c_8 Department + c_9\, CIT\ PRE + c_{10}\, SocialScience + c_{11}\, Technology + \varepsilon \quad [3]$$

4. Results

Considering the three areas (Business and Management, Social Sciences, and Technology), about 51% of cases were classified as blatant misconduct, 12% as inappropriate, and 28% as questionable. The blatant misconduct cases received 2,701 and 3,697 citations before and post-retraction, respectively. Regarding the highly influential citations, the blatant misconduct cases received 166 and 267 citations, respectively, before and after the retraction. 87.9% of retracted papers in Business and Management were considered blatant misconduct by disciplines. This proportion is significantly lower in Social Sciences (45.4%) and Technology (53.8%).

4.1. Differences among areas.

We have conducted a comparative analysis to explore the main differences among the three main disciplines described above: Business and Management, Social Sciences, and Technology. A one-way ANOVA was performed to compare the effect of disciplines on the following variables: Level of Misconduct (Misconduct), Days to retraction (DAYS), Number of authors, (TEAM), Journal Prestige (SNIP), Department recognition (Department), citation rates before (CIT_PRE) and after retraction (CIT_POST), difference CIT_POST-CIT_PRE (⊗CIT), Highly Influential Citation rate (HIC_PRE) before and after (HIC_POST) retraction, and the difference HIC_POST- HIC_PRE (⊗HIC).

The one-way ANOVA revealed that there were statistically significant differences between at least two groups in the following variables: i) Misconduct ($F=4.11$, $p = 0.008$); ii) Days ($F=5.77$, $p = 0.003$); iii) TEAM ($F=11.34$, $p < 0.001$); iv) SNIP ($F=11.42$, $p < 0.001$); v) Recognition ($F=4.84$, $p = 0.008$); vi) CIT_PRE ($F=4.53$, $p = 0.010$); vii) CIT_POST ($F=2.51$, $p = 0.082$); and viii) HIC_PRE ($F=9.70$, $p < 0.001$).

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Insert Table 2 about here

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Bonferroni's Test for multiple comparisons found the following differences. First, the misconduct severity, and the citation rates before and after were significantly higher in Business & Management and Technology than in Social Sciences. The time to retraction, SNIP, Department recognition, and HIC_PRE were significantly higher in Business & Management than in Soc. Sciences or Technology. Finally, the number of authors was higher in Technology than in Business & Management or Social Sciences.

Table 2 summarizes the results of the comparisons, and Table 3 the correlation matrix of the main variables.

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Insert Table 3 about here

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4.2.Regression Analysis.

Table 4 shows the coefficients for models [1], [2] and [3]. In column 1, the dependent variable is the Time to Retraction (TIME) measures in calendar days, in column 2, the citation rate post retraction (CIT_POST) is the dependent variable. Finally, column 3 shows the coefficients for the highly influential citation rate post-retraction (HIC_POST) as the dependent variable. We have found evidence that Misconduct, SNIP, and CIT_PRE do have a significant positive effect ($\boldsymbol{\beta} = 0.147$, $p<0.01$, $\boldsymbol{\beta} = 0.094$, $p<0.01$, $\boldsymbol{\beta} = 0.039$, $p<0.01$) on time to retraction. Figure 1a shows the coefficients' forest plot for Model 1. This result answers our research question 1 and supports the idea that the more severe infractions and the prestige of journals delay the retraction, probably due to these articles involving more sophisticated questionable research practices and, probably, they are more challenging to detect.

Regarding the model to estimate CIT_POST (column 2), we found that Days ($\boldsymbol{\beta} = 0.0001$, $p < 0.01$), SNIP ($\boldsymbol{\beta} = 0.226$, $p < 0.01$), Department ($\boldsymbol{\beta} = 0.022$, $p < 0.05$) and CIT_PRE ($\boldsymbol{\beta} = 0.131$, $p < 0.01$) have significant positive effects on CIT_POST. Figure 1a shows the coefficients' forest plot for Model 1. This model answers our research question 2, supporting that the prestige of journal (SNIP) and institution (Department)

foster the number of citations received. The citation rate before retraction confirms that the scientific community does not notice when a paper is retracted.

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Insert Table 4 about here

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The models concerning the highly influential citation analysis are shown in column 3 of Table 4, and Figure 1c shows the corresponding forest plot. SNIP (**β** = 0.321, $p < 0.05$), CIT_PRE (**β** = 0.008, $p < 0.05$), CIT_POST (**β** = 0.063, $p < 0.05$), and HIC_PRE (**β** = 0.638, $p < 0.05$) have a positive effect on HIC_POST. This result answers our research question 3 and supports the idea that retracted pieces of research cause a high influence on further papers, influenced mostly by the journal's prestige and the citation records before retraction. Overall, thanks to this analysis, we obtain some evidence that supports our assumption that sometimes scientists are standing on slippery shoulders.

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Insert Figures 1a, 1b, 1c about here

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4. Discussion and Conclusions.

Our study shows that post-retraction citations must be the subject of study in all areas, particularly in Business and Management. On the one hand, we found that retractions in these areas are more severe and published by more prestigious journals and authors from more prominent institutions. This could be an unintended consequence of a highly competitive among scholars in Business Schools. On the other, we found evidence that

some scientists are unaware of what papers have been retracted since they continue citing them after articles were withdrawn. This result reveals that journals should improve the mechanism to detect those manuscripts that continue citing retracted pieces of research, regardless of why they have been retracted (i.e., errors or scientific misconduct).

There are several limitations to our study. First, we need to explore some theoretical frameworks that allow us to set and test some hypotheses. Second, we should extend the analysis to those papers that cite retracted ones. Knowing the characteristics of the authors, journals, or institutions of the citing papers is relevant. Third, it can be interesting to explore the retractions data to the Business Schools' scores in some prestigious rankings such as the ones elaborated by the Financial Times, The Economist, or QS.

Finally, some further avenues of research can be taken from this study. In particular, due to its social relevance, we consider it essential to the consequences or the effects caused by retractions on the impact caused by research in Business & Management directly in firms or indirectly through education at undergraduate and postgraduate levels.

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Table 1. Definition of the variables used in the analysis (details in the paper)

Variables	Definition	Source
AREA	Business and Management, Social Sciences and Technology	RWDB
Misconduct	Degree of Misconduct: 1: Appropriate Conduct; 2: Questionable Conduct; 3: Inappropriate Conduct; and 4: Blatant misconduct.	Adapted from RWDB and Hall & Martin (2019)
TIME	Number of days between publication and retraction	RWDB
TEAM	Number of authors	RWDB
SNIP	Source Normalized Impact per Paper	Scopus
Department	Maximum institution's score in the ranking from CRWU	CRWU
CIT_PRE	Citation Rate before retraction $\frac{Citations\ Before\ retraction}{Retraction\ year-Publication\ year}$	Scopus
CIT_POST	Citation Rate post retraction $\frac{Citations\ After\ retraction}{2021-Retraction\ year}$	Scopus
ΔCIT	Change in citation rates (CIT_POST – CIT_PRE)	Scopus
HIC_PRE	Highly influential citation rate before retraction $\frac{Highly\ Influential\ Citations\ Before\ retraction}{Retraction\ year-Publication\ year}$	Semantic Scholar
HIC_POST	Highly influential citation rate post retraction $\frac{Highly\ Influential\ Citations\ After\ retraction}{2021-Retraction\ year}$	Semantic Scholar
ΔHIC	Change in citation rates (HIC_POST – HIC_PRE)	Semantic Scholar

Table 2. ANOVA results

Variable	Three areas	(1) Business & Management	(2) Social Sciences	(3) Technology	F p-value	Post-Hoc Significant Differences
Misconduct	3.06	3.08	2.88	3.12	4.11**	A>B, C>B
	(0.03)	(0.07)	(0.08)	(0.05)	0.008	
TIME	776	1,167	859	776	5.77**	A>B, A>C
	(30.15)	(83.32)	(83.00)	(39.61)	0.003	
TEAM	3.09	2.77	2.78	3.38	11.34***	C>A, C>B
	(0.06)	(0.11)	(0.13)	(0.09)	< 0.001	
SNIP	1.65	1.94	1.69	1.55	11.42***	A>B, A>C
	(0.03)	(0.09)	(0.09)	(0.04)	< 0.001	
Department	76.24	77.51	75.58	75.92	4.84**	A>B, A>C
	(0.24)	(0.53)	(0.54)	(0.30)	0.008	
CIT_PRE	1.13	1.61	0.71	1.35	4.53**	A>B, C>B
	(0.09)	(0.23)	(0.09)	(0.18)	0.010	
CIT_POST	1.88	2.39	1.42	2.26	2.51*	A>B, C>B
	(0.14)	(0.39)	(0.17)	(0.24)	(0.08)	
ΔCIT	0.77	0.78	0.71	0.90	0.57	
	(0.09)	(0.24)	(0.15)	(0.15)	(0.56)	
HIC_PE	0.084	0.19	0.05	0.06	9.70***	A>B, A>C
	(0.013)	(0.05)	(0.01)	(0.01)	< 0.001	
HIC_POST	0.095	0.19	0.09	0.07	1.06	
	(0.018)	(0.06)	(0.02)	(0.01)	0.347	
ΔHIC	0.015	0.003	0.042	0.009	0.86	
	(0.011)	(0.028)	(0.018)	(0.015)	0.424	
N	949	227	216	556	949	

Table 3. Means, standard deviations, and correlations.

		1	2	3	4	5	6	7	8
1	Misconduct	1.000							
2	TIME	0.139*	1.00						
3	TEAM	-0.043	-0.063	1.00					
4	SNIP	0.003	0.119*	0.007	1.00				
5	Department	-0.018	0.131*	0.194*	0.222*	1.00			
6	CIT_PRE	0.128*	0.217*	0.065	0.156*	0.173*	1.00		
7	CIT_POST	0.085	0.145*	-0.068	0.201*	0.177*	0.771*	1.00	
8	HIC_PRE	-0.050	0.128*	0.012	0.211*	0.179*	0.517*	0.543*	1.00
9	HIC_POS	0.033	0.011	0.022	0.131*	0.156*	0.431*	0.617*	0.688*

Obs. =949. Correlations larger than 6% are significant at the 5% level (two-tailed test).

Table 4. Regression Models

	Time to retraction (TIME)		Citation rate post-retraction (CIT_POST)		Highly influential citation rate post-retraction (HIC_POST)	
VARIABLES	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
TIME			0.0001***	(0.00005)	-0.0001	0.0001
Misconduct	0.147***	(0.464)	0.023	(0.057)	-0.179	0.125
TEAM	-0.097***	(0.029)	0.036	(0.045)	0.070	0.097
SNIP	0.094***	(0.036)	0.226***	(0.049)	0.321**	0.127
Department	0.010	(0.007)	0.022**	(0.010)	0.042	0.036
CIT_PRE	0.039***	(0.009)	0.131***	(0.009)	0.008**	0.062
HIC_PRE					0.638**	0.282
CIT_POST					0.063**	0.023
Soc. Sciences	-0.181	0.150	0.161	(0.157)	0.329	0.324
Technology	-0.130	0.097	0.339	(0.150)	-0.309	0.459
Constant	5.774***	0.516	-2.281***	(0.703)	-6.196**	2.983
Observations	552		494		401	
R^2	50.90		52.43			

t–statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Fig 1a: Model 1 (TIME)

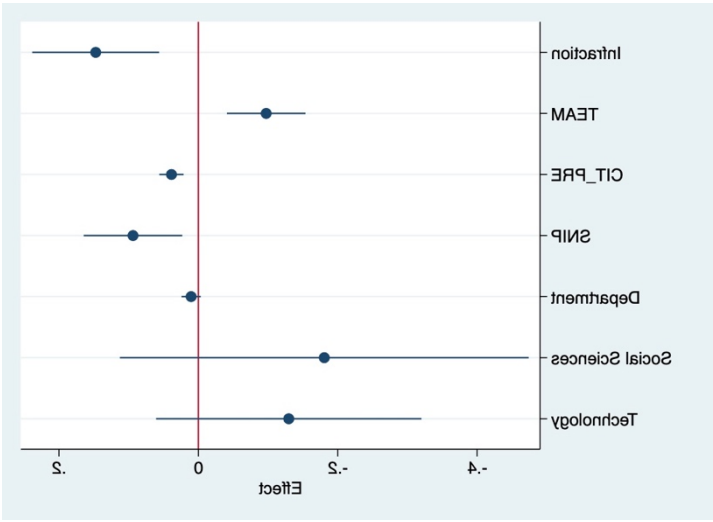

Fig 1b: Model 2 (CIT_POST)

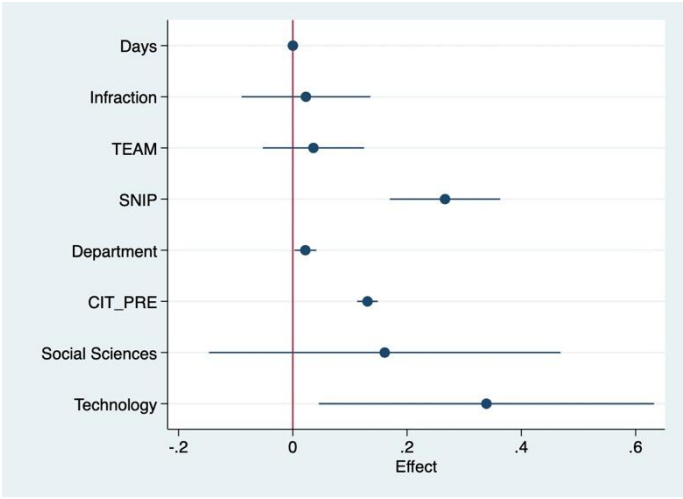

Fig 1c: Model 3 (HIC_POST)