東京大学 公共政策大学院
ワーキング・ペーパーシリーズ
GraSPP Working Paper Series
The University of Tokyo

GraSPP-DP-E-14-002 and STIG-DP-E-14-002

# Hidden Rationales behind Scientific Publication: a Case Study of Japanese Life Sciences

Sotaro Shibayama, Yasunori Baba

January 2014

GraSPP Discussion Paper E-14-002
STIG Discussion Paper E-14-002

GRADUATE SCHOOL OF PUBLIC POLICY
THE UNIVERSITY OF TOKYO
HONGO, BUNKYO-KU, JAPAN

GraSPP-DP-E-14-002 and STIG-DP-E-14-002

# Hidden Rationales behind Scientific Publication: a Case Study of Japanese Life Sciences

**Sotaro Shibayama[a,b,*], Yasunori Baba[a]**

**January 2014**

[a] The University of Tokyo, Research Center for Advanced Science and Technology
4-6-1 Komaba, Meguro-ku, Tokyo 153-8904, Japan.
Phone/Fax: +81-3-5452-5371.
e-mail: shibayama@00.alumni.u-tokyo.ac.jp
[b] The University of Tokyo, Department of Technology Management for Innovation
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656,Japan

GraSPP Discussion Papers can be downloaded without charge from:
http://www.pp.u-tokyo.ac.jp/research/dp/index.htm

**Graduate School of Public Policy**
**The University of Tokyo**
**7-3-1, Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan**
**Phone:+81-3-5841-1349**

**Hidden Rationales behind Scientific Publication: a Case Study of Japanese Life Sciences**


Sotaro SHIBAYAMA [a,b,*]

Yasunori BABA [a]

[a] The University of Tokyo. Research Center for Advanced Science and Technology.
4-6-1 Komaba, Meguro-ku,Tokyo 153-8904, Japan
Tel/Fax: +81-3-5452-5371
shibayama@00.alumni.u-tokyo.ac.jp

[b] The University of Tokyo. Department of Technology Management for Innovation.
7-3-1 Hongo, Bunky-ku,Tokyo 113-8656, Japan



## Abstract

Modern science relies on intense evaluation of scientific publication, often described as "publish or perish." However, the current science system seems to overlook the multifaceted nature of scientific publication. Though papers published in scientific journals are considered simply the output of science, they are, in fact, a collection of differently motivated products. Drawing on in-depth survey of professors in the Japanese biology sector, this study identifies the determinants of high and low-quality publications in an attempt to disentangle the complex rationales behind scientific publication. Results show that even productive academics with excellent publication records often produce low-quality papers and that such papers tend to be a by-product of student training and industry collaboration. In addition, results suggest that the practice of publication is strongly governed by certain norms formed through career. Inbred academics tend to avoid challenging projects while returnees from research experience abroad avoid publishing papers in low-impact journals. This study also investigates the impact of recent policies that emphasize competition and merit-based resource allocation, finding that the overconcentration of budget and human resources on selected academics actually facilitates low-quality publication.



## Keywords

Scientific production; publication; motivation; science policy; evaluation



[*] Corresponding author.

## 1. Introduction

Recent policies have increasingly emphasized the role of academic science in technological innovation and economic growth to boost scientific productivity (Etzkowitz and Leydesdorff, 2000; Stephan, 2012). Since scientific productivity is commonly measured on the basis of scientific publication, academics and research organizations are under intense pressure to publish (Hagstrom, 1974), often described as the doctrine of "publish or perish" (e.g., Anderson et al., 2007; Fanelli, 2010).

Despite the strong emphasis on productivity, it is debatable whether the current regime actually facilitates the progress of science. It is not difficult to find examples in which academics resort to rent-seeking behavior such as misconduct, abuse of authorship, and inadequate citation practices to inflate superficial productivity (e.g., Martin, 2013). Such misbehaviors set aside, there is a concern that recent policies may not contribute to the quality of science while probably increasing the quantity of publications. Recent years have seen a substantial increase in commercial journals, including countless online-access journals, not a few of which are criticized for dubious scientific legitimacy (Bohannon, 2013). In addition, a significant proportion of publications attract little scholarly attention in terms of citation. Laband and Tollison (2003) showed that the proportion of uncited papers in economics had been constant over two decades. Wallace et al. (2009) also report that uncited papers are common in many other disciplines. Though citation does not directly translate into quality (Macroberts and Macroberts, 1996), roughly speaking, the scientific contribution of rarely cited papers and unread journals should be limited (Cole and Cole, 1972). With this regard, current policies might be wasting resources on trivial research and creating burden for science. While rarely cited papers are more often produced in emerging countries, which are in the process of improving their scientific standards, such papers are universally observed (Figure 1). Importantly, low-quality publications can result from ill-designed policy interventions. An infamous example was reported on the Australian funding system, where the system was reformed so that research money is now awarded based on publication count, and academics started to produce more papers but of lower quality (Butler, 2003). "Salami slicing" is also an infamous unintended consequence, where academics fragment a single study into multiple papers to inflate publication count (Broad, 1981).

Intriguingly, focusing on the publication pattern at the individual level, we notice that productive academics do not always publish excellent papers, nor do unproductive academics always publish mediocre papers. As later shown, many academics produce both high and low-quality papers. This appears paradoxical especially when the qualitative aspect is highly regarded in every sort of evaluation system, which led us to question rationales behind such a publication pattern. The results of this study suggest that, though papers in scientific journals tend to be simply considered output of science, they are in fact a collection of differently motivated products, and that the motivation is affected differently by contexts. The goal of this study is to explore such multifaceted rationales behind scientific publication with micro-organizational contexts taken into consideration. In so doing, this study attempts to offer implications for science policy in better designing and implementing the incentive system of science.

To this end, the current study offers a case study of the Japanese biology sector with in-depth interviews and econometrical analyses based on a questionnaire survey and bibliometric data. We suppose that prior literature based on aggregate productivity measures (e.g., publication count, citation count) obscures the subtlety in publication. Our approach, however, disentangles the determinants of high and low-quality publication in an attempt to better understand the subtle nature of scientific production. The field of biology in Japan offers an interesting case in that Japan is highly ranked in life sciences (Adams et al., 2010) and yet commonly produces low-quality publications (Figure 1). Importantly, the Japanese science system is fairly free from extrinsic incentives (e.g., pay raise) for publication, which allows us to see some rationales for publication possibly hidden in other contexts. The implication from the case study is threefold. First, our results imply that scientific papers are produced for various reasons. Some publications are produced not for scientific progress but as a byproduct of other missions. Specifically in the Japanese context, results show that low-quality publications tend to be a by-product of student training and perhaps industry collaboration. Second, this study suggests that the choice of publication quality is influenced by the norms on quality. Academics have heterogeneous attitudes on engaging in low-quality research, on publishing in low-impact journals, and so forth. Results indicate that the norms are formed during the course of academics' career, particularly affected by inbreeding and mobility. Third, this study presents empirical evidence about the intended or unintended impacts of policy interventions in Japan on publication quality. Results suggest that Japanese policies fostering competition and concentration of resources (e.g., money and workforce) on productive academics actually lower publication quality.

This paper is structured as follows. Chapter 2 presents an overview of the literature on the reward system and publication. Chapter 3 outlines our data. Chapter 4 explores rationales behind scientific publication based on the literature review and our interviews, which are further explored by a survey and bibliometric data in Chapter 5. Finally, Chapter 6 discusses the results and summarizes policy implications.

## 2. Reward system and publication

A traditional view of Sociology of Science supposes that academics are obliged to publish their findings because they owe their discoveries to bodies of prior work published by predecessors (David, 2004).

While academics have to forgo exclusive rights to their discoveries through publication, they are rewarded by recognition and esteem from their peer academics (Merton, 1973). This reward system behind the regime of open science is self-sustaining inside the scientific community. While this remains indispensable, modern science has become increasingly interlinked with society and has been under stricter external control (Dasgupta and David, 1994; Etzkowitz and Leydesdorff, 2000). Policymakers and research organizations evaluate academics and allocate resources based on objective evidence, typically on publication record (Geuna and Martin, 2003; Hicks, 2012). With the aid of enriched bibliometric data and computational power, various measures of scientific productivity have been invented, such as the citation index and H-index (e.g., Hirsch, 2005; Narin and Hamilton, 1996), and incorporated into evaluation systems. Countries and research organizations are ranked with these measures, which has further reinforced political pressure for evaluation. Consequently, academics are forced to strive in the publish-or-perish regime (Hagstrom, 1974).

In modern science, most evaluation systems rely somewhat on bibliometric indices, among which citation plays a critical role with the straightforward premise that highly cited papers offer a good foundation for subsequent research (Cole and Cole, 1972). Thus, academics and research organizations are keen on receiving citations, though aware of the potential problems of citations (Macroberts and Macroberts, 1996). Their obsession with citation is easily observed in some anecdotes; for example, some journal editors were found to coerce authors to cite their papers in peer review (Wilhite and Fong, 2012), and some universities are known to offer part-time employment to highly cited academics with the condition that the university name be added in their publications (Bhattacharjee, 2011). These examples might be exceptional, but the current regime undoubtedly affects the practice of scientific publication. It is only natural that academics want to publish their papers in journals that are likely to invite many citations, so-called high-impact or prestigious journals, characterized by a high quality standard. Such journals attract more submissions, and this raises the quality of papers accepted by those journals. In this positive spiral, journal prestige has been substantiated and come to represent the value of papers published in them (Gordon, 1984; Ravetz, 1973).[1] Though the quality of papers in prestigious journals certainly varies (Oswald, 2007), publishing in prestigious journals of itself is regarded as a great scientific achievement. Evaluation systems explicitly or implicitly take into account the journal impact, and academics make a tremendous effort to publish in journals of as high an impact as possible (Frank, 1994; Gordon, 1984). These features of modern scientific publication are well captured by Holub's criticism that "especially *where* a scientist publishes has become much more important than *what* he is publishing"

[1] Although journal prestige may have weak consensus in social sciences, it attains a reasonable consensus in life sciences (Mcallister et al., 1980), which is the focal subject of this study.

(Holub et al., 1991).

While scientific merit is always emphasized, modern science is becoming heterogeneous. That is, not only research and education but also contribution to society is strongly demanded (Dasgupta and David, 1994; Etzkowitz and Leydesdorff, 2000). Among others, a recent trend called academic entrepreneurship encourages academics and research organizations to engage in commercial activities and university-industry relations (Etzkowitz and Leydesdorff, 2000). This diversifies the motivation of academics (Frickel and Moore, 2005; Shibayama, 2012), and importantly, it can crowd out the motivation to achieve scientific excellence by keeping academics busy on non-research missions.[2] In fact, some studies suggest inconsistency between commercial activities and scientific production while others show their compatibility (Baldini, 2008; Fabrizio and Di Minin, 2008).

## 3. Data

Overall, prior literature has identified a few mechanisms of scientific publication and their historical transition. On top of this general picture, the current study attempts to explore multifaceted rationales behind publication with micro-organizational contexts taken into consideration. To this end, we draw on a case study of the Japanese biology sector. We do not claim that the science system in Japan is representative, but we believe that it offers an interesting case for a few reasons. First, the Japanese science system is fairly free from extrinsic incentives for publication. Once academics obtain a full professorship, their income is basically determined by seniority with very limited influence of scientific productivity, and their status is secure till retirement even with no publication. This enables us to observe some rationales behind publication that might exist in general but have been hidden. Second, even with weak incentives, Japan is highly ranked in life sciences with a reasonable proportion of high-quality publications (Adams et al., 2010), while it produces an apparently higher rate of low-quality publications than other developed nations (Figure 1). Third, the Japanese science system is in a transition for recent reforms, and resulting heterogeneous policy contexts allow us to see variation in publication behavior. The modern science system in Japan started in the early 20$^{th}$ century, modeled on the German system (Kneller, 2007). However, since the 1990s, the government has been reforming various aspects of the system including funding, education, employment, promotion, and so forth. These reforms are intended to increase global competitiveness and have placed greater emphasis on merit-based evaluation and resource allocation, basically modelling the American system (Kneller, 2007).

[2] In such cases, it is not easy to evaluate the holistic impact to society; for example, even if quality of research is compromised, it might be compensated by commercial application.

We first conducted interviews of 30 principal investigators (PIs) of biology laboratories. We chose our interviewees from universities of a diverse range of organizational prestige to examine institutional differences. Each interview took 1-2 hours. We investigated interviewees' publication record based on bibliometric data and asked a series of questions about their specific publications. We further inquired into their publication strategies, the impact of recent policies, the evaluation criteria in their departments, and so forth.

To confirm and further explore the findings from the interviews, we conducted a questionnaire survey of PIs in 2010. We restricted our survey sample to professors who are the PI of a laboratory since they are the primary decision-makers in publication.[3] We selected PIs who received national grants in the field of biology at least once from 2007 to 2009 to make sure that they were active researchers. We prepared a list of 1,378 PIs drawing on a database of national research funds.[4] After re-examining their research fields and affiliations with public information, we chose 900 PIs in 56 universities as a final sample.[5] We designed our survey instrument based on the interviews. We mailed the survey and collected 400 responses (response rate = 44%).[6] For the 400 respondents, we collected publication data of approximately 12,000 articles that the respondents authored from 2006 to 2010 from Web of Science (WoS). We also obtained the Impact Factor (IF) data from Journal Citation Report (JCR).

## 4. Scientific Publication in Context

Drawing on interview results and literature review, this chapter explores how academics behave in scientific publication under specific organizational and policy contexts and how this affects the quality of publication.

In terms of a general trend of publication quality in Japan, most of our interviewees acknowledged that the Japanese system has been becoming quality-oriented, consistent with the policy intention. Simultaneously, informed about the higher rate of low-IF publication compared to other developed countries (Figure 1), they admitted that the Japanese system traditionally rewards for the volume of publication. On top

---

[3] In the Japanese chair system, associate and assistant professors may not be a PI but be supervised by another full professor.
[4] We used a database of Grants-in-Aid for Scientific Research, which is the primary competitive funding source for Japanese university researchers (http://www.jsps.go.jp/j-grantsinaid/index.html).
[5] The major player in academic science in Japan is national universities, and more recently private and other public (city and prefecture) schools joined the system though they are rather education oriented. As of 2010, Japan has 86 national universities (School Basic *Survey by Ministry of Education, Culture, Sports, Science and Technology:* http://www.e-stat.go.jp/), of which about 50 are engaged in some life science research. Our sample covers most of the relevant national universities and several private and other public schools.
[6] To examine the non-response bias in the survey, we randomly selected 50 non-respondents and found no significant difference between the response and non-response groups in publication productivity, organizational rank, and gender ($p > 0.1$).

of this general trend, our interviewees suggested that publication quality is affected at the micro-organizational level in three stages of academics' decision making (Table 1). First, since the roles of academic organizations have become diverse (Dasgupta and David, 1994; Hackett, 1990), academics have different priorities in those roles. Non-research missions can crowd out motivation aiming at scientific excellence or result in by-product publications primarily intended for non-research missions, where academics do not really care about their quality. Second, academics arrange a portfolio of projects to achieve their goals, with some academics concentrating only on high-quality research while others not. Such a choice of portfolio is importantly affected by research capacity, which substantially differs between laboratories under biased resource allocation. Third, academics can adopt different strategies in publication; for example, the choice of journals or the amount of effort in publication per se may differ even when identical research results are obtained. Such strategies are strongly governed by the norms on quality, which are formed through academics' career. In what follows, we discuss three key determinants of publication quality: 1) priority in multiple missions, 2) norms on quality, and 3) capacity for research.

### *4.1. Priority in multiple missions*

The mission of academic organization has been becoming diverse in history (Dasgupta and David, 1994; Hackett, 1990). In addition to research and education, recent policies worldwide have emphasized direct contribution of academic organizations to society in the forms of industry-university collaboration, technology transfer, commercial activities, and so forth (Etzkowitz and Leydesdorff, 2000; Geuna and Rossi, 2011). If these non-research activities are independent of research, effort for non-research missions should simply decrease output from research. However, these multiple missions are actually interrelated. For example, industry collaboration often leads to both scientific papers and patents (Baldini, 2008). Governmental consulting projects can result in both policy reports and scientific papers (Ynalvez and Shrum, 2011). Training of students may yield scientific papers along with a trained workforce (Shibayama et al., 2013). In these examples where academics simultaneously engage in multiple missions, it may be up to each academic's preference which mission comes as their first priority, but research is more likely to come secondary under the institutional emphasis on non-research missions. Our interviewees implied that this can affect publication quality in two ways. First, academics often produce scientific papers as a by-product of non-research missions, and they do not really care about the quality of such papers. Interestingly, our interviewees consistently suggested that the educational mission is an important source of by-product publications with mediocre quality in the Japanese context. Illustrating the design of typical PhD programs in Japan, a professor made the following comment:

> PhD students are usually allowed to graduate in three years [in addition to a two-year master program] even if their dissertation leaves some room for improvement. Thus, students have an incentive to wrap up their research even in a premature stage. In addition, since low-ranked universities often require a certain number of publications as a condition for graduation, PhD students tend to publish mediocre papers to earn a degree. PIs accept this practice from an educational point of view.

Another PI, referring to the competition in employment, said,

> PhD students have to prepare a compelling vita during the three years of the PhD program so that they can earn a job or fellowship after graduation. To this end, having a good publication record is vital. However, sticking to high-impact journals may be risky because it takes time and can end up with no publication. Thus, producing mediocre-quality but low-risk papers is a reasonable strategy for students.

Thus, in the context of the Japanese education system, while young academics are the indispensable workforce and possibly a source of serendipity (Shimizu et al., 2012; Stephan and Levin, 1992), they could undermine the potential value of publication.

Second, the emphasis on non-research missions can crowd out motivation to achieve scientific excellence. When the primary reward for academics is the recognition from peers conditioned on publication, publishing in prestigious journals should be academics' primary concern (Merton, 1973). However, as different types of activities are appreciated and incorporated into evaluation systems, the relative importance of scientific contribution should decline (Ynalvez and Shrum, 2011). In fact, literature finds heterogeneity in the motives of contemporary academics (Roach and Sauermann, 2010).

An obvious policy trend in Japan, as in other many countries, is academic entrepreneurship (Etzkowitz and Leydesdorff, 2000). Japanese universities have implemented infrastructure for patenting, licensing, and commercial activities (e.g., Nagaoka et al., 2009). Consequently, many academics have participated in these activities, and their focus of research has shifted from basic toward applied areas (Shibayama et al., 2012). Prior literature has shown mixed findings about the impact of this trend on scientific production (Baldini, 2008). On the one hand, an entrepreneurial and use-oriented approach can potentially induce fundamental breakthroughs also for pure science, as exemplified by the French scientist Louis Pasteur (Baba et al., 2009; Stokes, 1997; Subramanian et al., 2013). One PI referred to the downside of narrowly focusing on basic science:

> Typical PIs emphasizing pure science tend to shut themselves inside their labs, unwilling to engage in public relations. Though this may be efficient, it can limit the input of resources and information

> from outside. Successful PIs who are practically motivated seem to attract input from the public and the industry, which allows them to dynamically adjust their research direction and stay on the cutting edge.

In fact, Baba et al. (2012) find that a sizable proportion of Japanese material scientists produce both practically useful and scientifically important discoveries.

On the other hand, the trend can also cause both crowding-out and by-product effects. Concerning motivational crowding out, one interviewee mentioned:

> My perception on applied research is that not only scientific excellence but also other societal factors play an important role in employment, promotion, and funding. To be practically useful, academics cannot always stay inside their lab but they must engage in social interaction to transfer their knowledge to society. They simply spend more time on public relations or non-research activities to achieve societal contribution. This can weaken the incentive to pursue high-impact research.

Furthermore, it is well known that academics engaging in entrepreneurial activities tend to be secretive, thus compromising scientific quality in their publications (Walsh et al., 2007). Walsh and Huang (2007) find that Japanese academics are clearly secretive in publications coauthored with industry, suggesting that the goal of publication is more advertisement for industry partners than advancement of science. In addition, Hicks et al. (1996) reported that university-industry coauthored papers in Japan often resulted from the secondment of corporate researchers to university laboratories, where the coauthorship is intended to signal social commitment rather than indicate genuine scientific contribution. These observations imply that the emphasis on entrepreneurship can facilitate by-product publication possibly of mediocre quality.

### *4.2. Norms on quality*

Though the country-level overall quality standard appears to be improving in Japan (Morichika and Shibayama, 2011), some interviewees, particularly junior professors, suggested that there remains a gap in quality standards between older and younger generations, and that younger generations under intense pressure for competition are keener on quality. This implies that the norms on quality might persist once established under a certain context in early career stages.

The Japanese career system used to be, and still is partly, characterized by permanent employment and a high rate of inbreeding (Horta et al., 2011), while the reform has facilitated fixed-term employment and mobility (Morichika and Shibayama, 2011). The effect of inbreeding on productivity has been studied with inconclusive findings (e.g., Hargens and Farr, 1973; Inanc and Tuncer, 2011). One clear effect of inbreeding is to eliminate the pressure from external competition, which can affect productivity either positively by stabilizing the research conditions or negatively by giving academics room for slack. In terms of its effect on quality, our interview suggests that stability as well as slack affects quality more often negatively than positively. In general, PIs want their inbred subordinates to further the PIs' own research agenda because this will raise their reputation. In this scenario, subordinates would be obedient since they want to secure their future job. Even if PIs are generous enough to allow autonomy in subordinates' choice of research topics, subordinates have a reason to remain in established topics and avoid novel but risky ones. Furthermore, since the practice of lab work, including publication strategies, is usually passed down from PIs to their students (Delamont et al., 1997), inbred PIs would follow conventions formed in a volume-oriented regime. Consistently, one professor with a highly mobile career mentioned from his observation of inbred colleagues:

> In my impression, inbred academics tend to emphasize quantity of production more than quality. When junior academics earn a position of PI in a new affiliation, they have to bear a start-up cost and endure a temporary stall of production. Since this initial cost is substantial and cannot be compensated by publishing mediocre papers, mobile academics need to bet on risky but high-impact subjects. On the other hand, inbred PIs can maintain productivity, when their previous boss retires, by keeping the ex-boss's lab setup and maintaining the same research agenda even though such an approach might lack originality.

Thus, the practice of inbreeding seems to sustain traditional norms and deter academics from adopting quality-orientated publication strategies.

Such negative effects of inbreeding may be addressed by facilitating mobility. Among different types of mobility, our interviewees suggested that international mobility has a particularly strong effect. Japanese science policies have consistently encouraged international mobility to Western countries (mostly to the US), where the rate of high-quality publication is higher than in Japan (Figure 1). As prior literature suggested, mobility to those countries can produce a learning effect and a network effect, which directly improves productivity (Hoisl, 2007; Scellato et al., 2012). However, we assume that an equally or more important effect is that international mobility can change academics' quality standard. With a sample of economists, Hamermesh and Pfann (2012) suggest that publication count could have a negative effect on reputation in the US, implying that publishing many mediocre papers is looked down upon in the American academic culture. This is clearly different from the norms on quality, at least in the pre-reform Japanese system. Thus, the norms on quality seem to be shaped under the influence of geographically or culturally constrained contexts, and international mobility can help transform them. Our interviewees with foreign experience tended to emphasize quality and hold a negative view of mass production. Two interviewees who used to have professorships in the US made the following comments:

> I have a policy not to publish in journals with an Impact Factor (IF) less than 3.5. I would rather scrap my paper than to publish it in lower-impact journals. From my experience in the US, junk papers are not only unappreciated but also could harm my reputation. Besides, publishing in journals of very low IF (e.g., IF < 1) is pointless since it would not contribute to science.

> My perception is that academics in my field consider an IF around 4 a fair quality. Without having a publication of that class, it would be impossible to find a job in the US. I advise my lab members to keep this standard. Journals with an IF of 2 are minimally acceptable. Publishing in journals with an IF less than 1 is meaningless since nobody would read such journals.

Thus, in the Japanese context, international mobility seems to affect the norms on quality and accordingly encourage research and publication strategies with a stronger orientation for quality.

*4.3. Capacity for research*

Prior literature has shown that scientific production heavily relies on resource input (e.g., Jacob and Lefgren, 2011; Johnston, 1994). This should be the case particularly in biological research, which is highly resource-intensive as a result of its strong empiricism and dependence on experimental work (Bertalanffy et al., 1962). As is the global trend (Geuna and Martin, 2003; Hicks, 2012), the Japanese science policy has emphasized merit-based evaluation and resource allocation. This changes the distribution of research money and human resources, both strongly affecting the research capacity of biology laboratories.

The Japanese funding system consist of roughly two parts; non-competitive block grants for universities, part of which is redistributed to faculty members, and competitive grants for individual academics. In the reform, non-competitive block grants have been gradually replaced by competitive grants, and research money has been increasingly concentrated on selected universities and individuals. Shibayama (2011) investigated the distribution of national funds at the individual and university levels and found disproportionately large grants for limited academics and the practice of multiple awarding (i.e., one academic receives many grants simultaneously).[7] From policymakers' viewpoint, it may be reasonable to concentrate the budget on productive researchers rather than distributing a small amount of money to everyone. In fact, literature suggests that high-impact publication tends to be produced with the support of large funding (Shimizu et al., 2012). However, this does not necessarily mean that all large budgets are efficiently used.

From the interviews, we found that large budgets could cause some undesirable consequences. The most straightforward is that academics start carelessly spending money, though this may not affect research quality. Another wasteful but natural reaction of PIs who receive more budget than necessary is that they attempt to use up all the money rather than to return it to the funders. Since a PI has a limited number of research ideas, PIs with excessive budgets often try their second and third best ideas, knowing that these may lead to only mediocre results. Furthermore, PIs can exploit a large budget more strategically. Scientific research is highly unpredictable, and the risk may be lowered by running many projects. Such a strategy is totally legitimate though it is debatable whether the portfolio should be arranged inside each laboratory or collectively among the community. Problematically, our interviewees suggested that some PIs recklessly carry out numerous projects without carefully designing them, hoping that a few of them by chance turn out innovative at the cost of many mediocre results. Two interviewees critically made the following comments:

> One typical strategy for mass production is to slightly modify someone else's prior studies so that they can produce some results with a minimum effort. Though such an approach is unlikely to yield high-impact results, it sometimes accidentally gives interesting results. If a budget is sufficiently large, this approach could produce high-impact publications constantly.

> Pursuing originality is psychologically tough because of the high risk involved. Compared to that, a mass production strategy mimicking or following others' research is much easier. What PIs have to do is to raise funds and arrange facilities. Then, as many publications as the number of students would come out almost automatically though their quality is questionable.

The payoff of these strategies would be acceptable when efficiency is disregarded in evaluation. In addition, once PIs are accustomed to large budgets, they have difficulty in downsizing their laboratory. Laying off research staff is stressful, and the cost of operating large devices is high. In such cases, maintaining revenue size can become a PI's priority over pursuing scientific excellence (Sousa, 2008); i.e., they act more like a revenue-maximizer than a profit-maximizer. One senior professor about to retire made the following comment:

[7] The government has attempted to mitigate these issues after criticism from science communities.

> I was awarded a large grant in my early career. Once I got used to it, I kind of wanted to have the same amount of budget continuously. Having a lot of money is not bad, but writing funding proposals and reporting is time-consuming. Looking back on my career, I regret that I should have used my time more on research itself than on funding.

In sum, though we agree that the productivity of biology research should depend on budgetary input (e.g., Jacob and Lefgren, 2011), too large a budget could compromise quality.

In addition to research budgets, the reform has increased the bias in the distribution of human resources. The primary research workforce in Japanese universities is PhD students rather than postdocs. A reform, in an attempt to reinforce graduate education, doubled the overall quota of graduate students during the 1990s. However, this has yielded numerous PhDs and postdocs without stable employment, and the apparently bleak prospect of an academic career has significantly decreased PhD enrolment especially in low-ranked universities during the last decade. Consequently, the reform has created an unequal distribution of PhD students among universities. A director in a local university said,

> In the past, we used to attract 200 applicants for 50 seats of the PhD course. The situation has largely changed after the reform, especially after the University of Tokyo [one of the top universities] was allowed to increase its PhD quota, which took all the good students away. We have barely filled our quota in recent years.

The effect of lab size on scientific production, though well studied, remains inconclusive. Cohen (1981) reported that publication count per researcher is constant regardless of lab size. Likewise, Johnston (1994) suggested that productivity does not improve with size, but that below a critical mass of lab size, typically 5-8 researchers, productivity declines. Focusing on PhD education, Salonius (2008) observed that the quality of student training worsens when lab size increases and PIs cannot spend sufficient time on each student. This implies that the quality of students' projects may be sacrificed in laboratories with too many students. In fact, a senior PI of a medium-sized laboratory said,

> I am not interested in expanding my laboratory. I want to concentrate on thoroughly-planned and well-selected projects in a modest sized lab. Considering my own capacity, I could not come up with a greater number of promising projects than I currently do. If I accepted more students, I would have to assign them improvised or mediocre projects. Currently, my students publish reasonably good papers in good journals, but mediocre papers would be inevitable in a larger lab.

In line with this opinion, another professor criticized PIs in top universities:

> Some PIs in top universities accept many students and produce numerous papers. A problem is that students in such big labs have to compete with one another inside the small world of labs, and some of them inevitably end up losers and become demotivated. I believe that even those losers would be stars and much more productive in a less competitive environment. The excessive concentration of students in top universities has compromised holistic productivity.

In sum, excessive concentration of students can be counterproductive, while we agree that a certain lab size is essential in labor-intensive biological research (Johnston, 1994).

## 5. Regression Analysis of the Determinants of Publication Quality

### *5.1. Analytical approach*

This chapter further explores the findings in the previous chapter with a survey and bibliometric data. Our analytical approach draws on the quality-based portfolio of scientific publication at the individual level; that is, we collected the data of scientific papers published by an individual academic in a certain period and analyzed the distribution of quality among the collection of papers. A typical measure of publication quality is citation count (e.g., Garfield, 1972), but for the following reasons, we draw on the distribution of Impact Factors (IFs) of the journals where our respondents published their papers. IF is a measure of quality or prestige at the journal level.[8] Though IF is a controversial index (e.g., Denrell and Liu, 2012), it has attained a high consensus particularly among life scientists (Mcallister et al., 1980) and is incorporated in science systems. In fact, our interviewees suggested that their perceived quality of journals reasonably agree with IFs, and that IFs are, explicitly or implicitly, in common use in formal evaluations, though they express a concern in excessive emphasis on IFs. As a result, the decision of academics and research organizations is strongly influenced by IFs in some fields where academics' perceptions of journal quality and IFs coincide well (Frank, 1994; Gordon, 1984). Thus, we believe that academics' choice of journals in terms of IFs well reflects their motives and is probably more directly affected by policy and organizational contexts than citation count is. Of course, journal choice can be beyond academics' control (i.e., submitted papers may be rejected), but Calcagno et al. (2012) show that authors usually know where their papers will be accepted, and approximately 70% of

[8] IF is defined as "the number of current citations to articles published in a specific journal in a two year period divided by the total number of articles published in the same journal in the corresponding two year period" (http://ip-science.thomsonreuters.com/support/patents/patinf/terms/).

published papers are accepted by the journals to which they are first submitted. That is, authors recognize the quality of their own papers and submit them to journals of suitable IFs.

To identify the determinants of high and low-quality publication, we categorize journal classes and investigate the explanatory factors for publication in each class. Based on our interviews, we categorize four journal classes; very low quality (IF<1), low quality (IF=1-2), middle quality (IF=2-8), and high quality (IF>8). Our interviewees suggested an intuitive threshold, saying that "IF<1 means that papers in the journal would be read [i.e., cited] only once [in two years], and publishing a paper in such journals makes no impact on science."[9] We set another less stringent threshold of IF<2. Interviewees also suggested that IF=7-8 or above is regarded as high quality, so we consider IF>8 as high quality. The 12,000 articles that our respondents published from 2006 to 2010 comprise 7% very-low, 14% low, 69% middle, and 10% high-quality publications.[10]

### *5.2. Measurement*

#### *5.2.1. Dependent variables*

We run regressions at the individual level, and supplementarily, at the article level. As article-level measures, we prepared dummy variables of *IF<1*, *IF<2*, and *IF>8*. To make our analyses comparable to those in prior literature, we also use adjusted citation count of each paper.[11] As individual-level measures, we computed the percentage of each IF class: *%IF<1*, *%IF<2*, and *%IF>8*. We also computed the publication count and the summation of the adjusted citation count for all papers published by each respondent during the five-year period. On average, our respondents published 6.6 papers per year. Figure 3 illustrates the quality-based portfolio of publication by plotting %IF<2 and %IF>8, suggesting that most PIs publish both high and low-quality papers. One concern regarding the use of IFs is that IFs are field-dependent (Seglen, 1997). Though our sample is restricted to biology, it includes multiple subfields. To address this issue, we also computed field-adjusted IF classes.[12] Since regression results with non-adjusted and adjusted measures are

---

[9] This threshold may appear too strict for social scientists since IF<1 is not uncommon in many social sciences fields. This is not the case in life sciences as later explained.

[10] The majority of the 12,000 articles were published in the subject category of "Biochemistry & Molecular Biology (BMB)," which is the second largest in WoS. In 2010, about 64,000 articles were published in BMB worldwide, and each IF class accounted for 5%, 14%, 74%, and 8% from very low to high quality (Appendix 1).

[11] Since recent papers should have fewer citations than old papers, we divided the citation count of each paper by the number of years elapsed since its publication (Shibayama et al., 2013).

[12] In each Subject Category of WoS, all journals registered to JCR2010 are sorted with respect to IFs. With BMB used as a base, we defined high-quality and low-quality journals; i.e., a journal is defined as high-quality if its ranking is comparable to IF>8 journals in BMB, and a journal is defined as low-quality if its ranking is comparable to IF<2 journals in BMB. This adjusted measure is not perfect, either. When IFs in a certain field are generally low (or high), it may be due to field-specific citation practices but it might be due to truly low (or high) quality of science in the field. We suppose that the true quality is somewhere between the adjusted and non-adjusted measures. As later shown, results from both measures are qualitative similar, which lends

qualitatively similar (Appendix 2), we primarily report results with non-adjusted measures.

### *5.2.2. Independent variables*

To measure research orientation, we asked: "Which describes your research goal, basic (aiming at advancement of theory and knowledge) or applied (aiming at solving problems in the real society)?" using a five-point scale, 1 = mostly basic, 2 = more basic than applied, 3 = both to a similar extent, 4 = more applied than basic, and 5 = mostly applied (*applied research*). Furthermore, with the publication data, we identified industry partners in the author list of each paper. We prepared a dummy variable at the article level, assigning one if at least one author was from industry (*industry coauthor*), and another dummy variable at the individual level, assigning one if at least one paper was coauthored with industry in the five-year period (*industry collaboration*). To examine the possibility of by-product publication due to student training, we identified PhD students included in the author list of each paper.[13] Since the first author tends to be the primary contributor in biology papers, we prepared a dummy variable, assigning one if a paper's first author is a PhD student (*student first author*), which we use for article-level regressions. In addition, we inquired into time allocation. We measured *time for research, teaching,* and *administration* based on the number of hours per week spent on each activity with a six-point scale: 1 = less than 10 hours, 2 = 10-20 hours, 3 = 20-30 hours, 4 = 30-40 hours, 5 = 40-50 hours, and 6 = 50 hours or more.

As for variables on career, we measured PIs' generation by the number of *years since the first degree*. In addition, we prepared two measures for the mobility of academics. We measured international mobility with a 6-point scale: 1 = none, 2 = less than half a year, 3 = one year, 4 = 2 years, 5 = 3 years, and 6 = 4 years or more (*foreign experience*). Examining curriculum vitae, we found that the majority of foreign experience occurred in the US. We also measured inbreeding with a dummy variable, assigning one if respondents earned their PhD in the current laboratory and zero otherwise (*inbred*).

As for research capacity, we asked the number of PhD holders (i.e., senior staff and postdocs) and PhD students, respectively, in each respondent's laboratory. We control for the number of PhD holders (*#staff*) as a lab-size measure. To measure the extent of workforce concentration, we divided the number of PhD students by the number of PhD holders (*#PhD/#staff*) with the assumption that students are supervised and trained by experienced researchers. We then asked about the total research budget in the year of 2010. To

---

some confidence in the interpretation of our results.

[13] The Japanese National Library provides the database of PhD dissertations (http://opac.ndl.go.jp/), where we downloaded the list of PhD graduates during 2006-2013. Considering that the PhD course in Japan generally takes three years, the list should cover most PhD graduates who were students during 2006-2010. With the publication year, full author name, and affiliation from WoS, we matched the publication data with the dissertation data and identified PhD students in the author list of each paper.

measure the extent of budget intensity, we divided the total budget by the number of all lab members (*budget/#member*) (in million JPY; roughly 1USD = 100 JPY).

We attempt to control for the PIs' innate ability by computing the adjusted citation count before they earned tenure positions (*#adjusted cite before tenure*). We also control for institutional capital by university rank based on the amount of competitive funding with a four-point scale: 4 = 1st or 2nd, 3 = 3rd-7th, 2 = 8th-20th, and 1 = 21st or below (*univ rank*).[14] We also control for gender (*female*). At the article level, we control for the number of authors (*#author*) and the number of organizations (*#organization*) listed in the author information. Table 2 presents the descriptive statistics at the individual level.

### *5.3. Determinants of publication quality*

#### *5.3.1. Multiple missions*

Table 2 presents the regression results with five dependent variables at the individual level: the percentage of papers in IF<1, IF<2, and in IF>8 journals, publication count, and adjusted citation count.

First, we examined the effect of entrepreneurial orientation. Engagement in applied research shows a negative effect on high-quality publication (Model 3: $b = -1.60$, $p < .01$) and a positive effect on low-quality publication (Model 2: $b = 3.06$, $p < .01$). However, industry collaboration shows a tendency to decrease low-quality publication (Model 1: $b = -4.76$, $p < .01$; Model 2: $b = -4.17$, $p < .05$). Thus, if research is not only applied but also actually applicable to industrial needs, it could increase the quality of research. This agrees with the argument of Pasteur scientists (Stokes, 1997). However, reverse causality is possible; academics producing high-quality research attract industry partners.

To further examine the effect of industrial collaboration, we also ran the article-level regressions in Table 3. Results in Table 3A are mostly consistent with those in Table 2, but the dummy variable of industry coauthorship does not show a significant effect. For closer inspection, we include in Table 3B two dummy variables assigning the value of one: 1) if the particular article is coauthored with industry, and 2) if the particular article is not coauthored with industry but the respondent had at least one industry-coauthored paper in the past five years. Results show that the latter variable has a significantly negative effect on low-quality publication (Model 1: $b = -.383$, $p < .05$; Model 2: $b = -.214$, $p < .1$), consistent to the individual-level analysis. However, the former variable has an insignificant effect with a smaller magnitude. Thus, the positive effect due to industry collaboration decreases if a paper is coauthored with industry partners. This supports the argument that industry collaboration might compromise quality due to secrecy or that such papers are published more for

[14] This categorization is based on the fact that top seven universities in Japan enjoy prestigious status as pre-imperial universities, and that Universities of Tokyo and Kyoto are exceptional among others.

advertisement than for scientific progress. Overall, a possible cynical scenario is that industries tend to be attracted by productive academics with the intention to exploit the collaboration for non-academic objectives and publish papers of mediocre quality.

Second, concerning the effect of student training, Table 3A introduces a dummy variable of whether the first author is a PhD student. The effect is unclear; significant only for IF<2 (Model 2). Since the ability of PhD students can significantly differ with university ranks (Shibayama et al., 2013), we incorporated the interaction term between student first author and university rank (Table 3C). The result suggests that high-quality publication is facilitated when a paper is first-authored by students in high-ranked universities. However, in low-ranked universities, student-led papers are of significantly lower-quality.[15] The former result may be consistent with the argument that young academics are the source of serendipity (Stephan and Levin, 1992). The latter result, on the other hand, suggests that student training may lead to by-product mediocre publication.

Third, we investigate the effect of time allocation. Time for research has a significantly positive effect on high-quality publication (Model 3: $b = 1.22$, $p < .01$) but not on low-quality publication (Models 1 and 2). Our interviewee suggested that high-quality research takes deep thought and is time-consuming. Thus, it is likely that only those who can afford sufficient time produce high-quality research. Since time for research does not increase publication count but rather decreases it (Model 4), academics with greater research time seem to concentrate on high-quality research but not to engage in many projects. Time for administration significantly lowers quality (Model 1: $b = 2.22$, $p < .001$; Model 3: $b = 2.79$, $p < .01$). Since this occurs after time for research is controlled for, administrative effort might crowd out the motivation to achieve scientific excellence. Time for teaching has no significant effect.

### *5.3.2. Career and norms on quality*

As for the norms on quality, we examined a few career factors. First, the results show that the number of years since the first degree is positively associated with low-quality publication (Model 2: $b = .30$, $p < .1$) and negatively with high-quality publication (Model 3: $b = -.27$, $p < .01$). This is consistent with the observation that younger generations are keener on quality than older generations.

Foreign experience shows a negative effect on low-quality publications (Model 1: $b = -1.64$, $p < .001$; Model 2: $b = -1.90$, $p < .01$) but only a weakly positive effect on high-quality publications (Model 3: $b = .59$, $p < .1$). It also decreases publication count (Model 4: $b = -1.79$, $p < .05$). Therefore, returnees from foreign experience may not only avoid low-quality research but also choose not to submit low-quality papers for publication. In addition, we dichotomize the variable with different thresholds (the original measure is

[15] The effect of student first author on high-quality publication is -.363 (= -.583 + 1 * .220) in bottom-ranked universities (univ rank = 1) and +.297 (= -.583 + 4 * .220) in top-ranked universities (univ rank = 4).

six-point scaled) and find that foreign experience longer than one year changes the portfolio of publication quality. That is, too short a stay may not affect academics' norms but that a one-year or longer stay facilitates normative assimilation.

Inbreeding shows a negative effect on high-quality publication (Model 3: $b = -4.47$, $p < .01$) and a weakly positive effect on low-quality publication (Model 2: $b = 5.58$, $p < .1$). The strongly negative effect on high-quality publication implies that inbred academics tend not to engage in challenging and novel subjects.

### *5.3.3. Research capacity*

As for research capacity, we examined the effect of resource input with three variables: the number of staff, per-staff PhDs, and per-member budget. The number of staff is positively associated with publication count and citation count (Model 4: $b = 4.08$, $p < .001$; Model 5: $b = 8.03$, $p < .001$) and so is per-staff PhDs (Model 4: $b = 9.63$, $p < .05$; Model 5: $b = 25.20$, $p < .05$). Budget also shows a positive effect (Model 4: $b = 1.40$, $p < .05$; Model 5: $b = 3.82$, $p < .05$). These results are consistent to prior findings that scientific production depends on resources. On the portfolio of publication quality, results basically show that research capacity is positively associated with high-quality publications (Model 3) and negatively associated with low-quality publications (Models 1 and 2). These results are consistent with the assumption that biology research is resource- and labor-intensive (Jacob and Lefgren, 2011; Johnston, 1994).

However, the quadratic terms imply that the effect is diminishing. The quadratic term of per-staff PhD shows a negative coefficient on high-quality publication (Model 3: $p = -1.12$, $p < .1$). Per-staff PhD shows no effect on low-quality publication (Models 1 and 2). Therefore, PhD students may be the source of high-quality research, but this effect is compromised when a laboratory accepts more students than its staff can oversee, possibly due to overcapacity for training. The result implies that one staff member can supervise at most two PhD students effectively (as far as high-IF publications are concerned).

Research budget also shows a diminishing effect. The quadratic term of budget has a negative coefficient on quality (Model 1: $b = .02$, $p < .1$; Model 2: $b = .06$, $p < .01$; Model 3: $b = -.03$, $p < .001$). Thus, excessive budget compromises quality. A budget larger than 20 million JPY (approximately 200K USD) per member per year is likely used inefficiently. Since the quadratic term on publication count is insignificant (Model 4), a larger budget linearly yields more papers, but their quality starts to decline at some point.

## 6. Discussion and conclusions

Modern science is characterized by the doctrine of publish or perish with a strong emphasis on evaluation of scientific publication (Fanelli, 2010), but its impact on the progress of science has been controversial. For example, recent years have seen a great increase in journals of questionable scientific quality (Bohannon, 2013), and a significant proportion of publications remain unread or uncited (Wallace et al., 2009). Intriguingly, academics who are capable of producing excellent papers are found to produce also low-quality papers even under quality-oriented evaluation systems. To explicate this seemingly paradoxical behavior and to explore the rationales of scientific production in general, this study examines the quality-based portfolio of publication to disentangle complex rationales behind publication. Drawing on a case study of the Japanese biology sector with in-depth interviews and a questionnaire survey, this study reveals distinctive determinants of low and high-quality publication. We believe that this approach highlights the multifaceted nature of scientific production that prior literature based on conventional productivity measures (e.g., citation count) might have overlooked. For example, our results indicate that excessive funding can lead to low-quality publication, but such an effect is overshadowed if the aggregate citation is counted.

This study offers three implications for future research and science policy. First, this study indicates that scientific papers are produced for many different reasons, and that they may be different sorts of products from authors' viewpoints even if they appear the same to policymakers and administrators. In particular, our results imply that some papers are published as a by-product of student training and industry collaboration. Thus, evaluating publication purely on its scientific merit might be misleading, especially when the role of academic organizations has become diverse in modern science (Dasgupta and David, 1994; Hackett, 1990).

Second, this study suggests that publication quality is governed by the norms on quality, which can substantially differ with academics' career process such as inbreeding and mobility. Particularly, in the Japanese context, we found that returnees from foreign experience (mostly from the US) tend to demonstrate peculiar norms; they despise low-quality research and are unwilling to publish in low-IF journals. In fact, returnees publish fewer papers than their domestic counterparts, to which two interpretations could be given. One is that returnees may concentrate on high-quality and time-consuming research, while the other is that they scrap papers that are rejected or likely to be rejected by high-impact journals. Our interview implies that the latter is the case to some extent. In line with our finding, prior literature shows that negative data tend not to be published, criticizing policies excessively emphasizing impact of publication (Dwan et al., 2008; Fanelli, 2010). Though papers published in low-impact journals offer a weaker scientific contribution, on average, this does not mean that they are useless. The norms on quality observed in our Japanese case and presumably shared widely in American academics (Hamermesh and Pfann, 2012) may deter the disclosure of scientific discoveries.

Third, this study offers empirical evidence of a detrimental effect of specific Japanese policies on scientific production. The policies have emphasized competition and concentration of budget and human resources on productive academics with the intention of fostering high-quality research. However, our results indicate that excessive resource input can actually compromise quality. Possibly, academics with abundant resources might resort to mediocre ideas, or they might employ mass-production strategies without a thorough design, hoping for accidental success. Furthermore, overconcentration can compromise the diversity of research. Emphasis on competition and merit-based resource allocation is a global trend (Geuna and Martin, 2003; Hicks, 2012). Taken together with the so-called Matthew effect (Merton, 1973), such policies could lead to unjustifiably biased resource allocation. These results call for rethinking the evaluation systems in modern science. Our results also imply that mobility policy can affect academics' norms and their publication strategies, and that the complex mix of academics' missions can change publication quality. Since science polices similar to those of recent Japan are commonly observed in other countries, their impact on scientific production should be further examined with each country's context for future development of science policies.

In sum, this study attempts to shed light on the complex rationale behind scientific publication and to inform the policy debate on the evaluation of scientific publication. Some limitations needs to be addressed in future research. One obvious limitation is its sample specificity in terms of the country and scientific field. We believe that the unique context of the Japanese system offers some advantage for the goals of this study, but external validity needs to be examined in future research. Second, publication quality is affected at multiple stages of academics' decision making (i.e., choice of missions, projects and journals). Future research should add empirical evidence about the impact of specific factors on those different stages. Third, IF needs cautious interpretation. Given that IF attains a reasonable consensus in life sciences (Mcallister et al., 1980), we suppose that our dependent variables reflect academics' motives and are strongly affected by policy and organizational contexts. Nevertheless, we cannot deny the limitations of IFs (Seglen, 1997). Fourth, for the nature of cross-sectional data, the possibility of endogeneity cannot be ruled out. Future research should test the impact of a specific policy intervention with dynamic data.

**Acknowledgments**

We would like to acknowledge David N. Laband, John P. Walsh, and Miho Funamori for guidance and comments. We would also like to thank Noriyuki Morichika and Naohiro Shichijo for technical support. Funding for this research was provided by the Konosuke Matsushita Memorial Foundation, Inamori Foundation, Grant-in-Aid for Encouragement of Young Scientists (B) of the Japan Society for the Promotion of Science (#24710160), and Grant-in-Aid for Scientific Research (B) Program (#23330121) form The Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan.

## References


Adams, J., King, C., Miyairi, N., Pendlebury, D. 2010. Global research report japan. Leeds, UK: Thomson Reuters.

Anderson, M. S., Ronning, E. A., De Vries, R., Martinson, B. C. 2007. The perverse effects of competition on scientists' work and relationships. ***Science and Engineering Ethics***, 13: 437-461.

Baba, Y., Shichijo, N., Sedita, S. R. 2009. How do collaborations with universities affect firms' innovative performance? The role of "pasteur scientists" in the advanced materials field. ***Research Policy***, 38: 756-764.

Baba, Y., Shichijo, N., Sedita, S. 2012. Comparing the contribution of differently motivated scientists: Pasteur vs. Bohr, ***Academy of Management Meeting***. Boston, Massachusetts.

Baldini, N. 2008. Negative effects of university patenting: Myths and grounded evidence. ***Scientometrics***, 75: 289-311.

Bertalanffy, L. V., Rapoport, A., Meier, R. L. 1962. ***General systems yearbook***. Washington, D.C.: Society for General Systems Research.

Bhattacharjee, Y. 2011. Citation impact saudi universities offer cash in exchange for academic prestige. ***Science***, 334: 1344-1345.

Bohannon, J. 2013. Who's afraid of peer review? ***Science***, 342: 60-65.

Broad, W. J. 1981. The publishing game - getting more for less. ***Science***, 211: 1137-1139.

Butler, L. 2003. Explaining australia's increased share of isi publications - the effects of a funding formula based on publication counts. ***Research Policy***, 32: 143-155.

Calcagno, V., Demoinet, E., Gollner, K., Guidi, L., Ruths, D., De Mazancourt, C. 2012. Flows of research manuscripts among scientific journals reveal hidden submission patterns. ***Science***, 338: 1065-1069.

Cohen, J. E. 1981. Publication rate as a function of laboratory size in 3 biomedical-research institutions. ***Scientometrics***, 3: 467-487.

Cole, J. R., Cole, S. 1972. Ortega hypothesis. ***Science***, 178: 368-&.

Dasgupta, P., David, P. A. 1994. Toward a new economics of science. ***Research Policy***, 23: 487-521.

David, P. A. 2004. Understanding the emergence of 'open science' institutions: Functionalist economics in historical context. ***Industrial and Corporate Change***, 13: 571-589.

Delamont, S., Parry, O., Atkinson, P. 1997. Critical mass and pedagogic continuity: Studies in academic habitus. ***British Journal of Sociology of Education***, 18: 533-549.

Denrell, J., Liu, C. 2012. Top performers are not the most impressive when extreme performance indicates unreliability. ***Proceedings of The National Academy of Sciences of The United States of America***, 109: 9331-9336.

Dwan, K., Altman, D. G., Arnaiz, J. A., Bloom, J., Chan, A. W., Cronin, E., Decullier, E., Easterbrook, P. J., Von Elm, E., Gamble, C., Ghersi, D., Ioannidis, J. P. A., Simes, J., Williamson, P. R. 2008. Systematic review of the empirical evidence of study publication bias and outcome reporting bias. ***Plos One***, 3.

Etzkowitz, H., Leydesdorff, L. 2000. The dynamics of innovation: From national systems and "mode 2" to a triple helix of university-industry-government relations. ***Research Policy***, 29: 109-123.

Fabrizio, K. R., Di Minin, A. 2008. Commercializing the laboratory: Faculty patenting and the open science environment. ***Research Policy***, 37: 914-931.

Fanelli, D. 2010. Do pressures to publish increase scientists' bias? An empirical support from us states data. ***Plos One***, 5.

Frank, E. 1994. Authors criteria for selecting journals. ***Jama-Journal of the American Medical Association***, 272: 163-164.

Frickel, S., Moore, K. 2005. ***The new political sociology of science***. Madison, WI: The University of Wisconsin Press.

Garfield, E. 1972. Citation analysis as a tool in journal evaluation - journals can be ranked by frequency and impact of citations for science policy studies. ***Science***, 178: 471-+.

Geuna, A., Martin, B. R. 2003. University research evaluation and funding: An international comparison. ***Minerva***, 41: 277-304.

Geuna, A., Rossi, F. 2011. Changes to university ipr regulations in europe and the impact on academic patenting. ***Research Policy***, 40: 1068-1076.

Gordon, M. D. 1984. How authors select journals - a test of the reward maximization model of submission behavior. ***Social Studies of Science***, 14: 27-43.

Hackett, E. J. 1990. Science as a vocation in the 1990s - the changing organizational culture of academic science. ***Journal of Higher Education***, 61: 241-279.

Hagstrom, W. O. 1974. Competition in science. ***American Sociological Review***, 39: 1-18.

Hamermesh, D. S., Pfann, G. A. 2012. Reputation and earnings: The roles of quality and quantity in academe. ***Economic Inquiry***, 50: 1-16.

Hargens, L. L., Farr, G. M. 1973. Examination of recent hypotheses about institutional inbreeding. ***American Journal of Sociology***, 78: 1381-1402.

Hicks, D. 2012. Performance-based university research funding systems. ***Research Policy***, 41: 251-261.

Hicks, D. M., Isard, P. A., Martin, B. R. 1996. A morphology of japanese and european corporate research networks. ***Research Policy***, 25: 359-378.

Hirsch, J. E. 2005. An index to quantify an individual's scientific research output. ***Proceedings of The National Academy of Sciences of The United States of America***, 102: 16569-16572.

Hoisl, K. 2007. Tracing mobile inventors - the causality between inventor mobility and inventor productivity. ***Research Policy***, 36: 619-636.

Holub, H. W., Tappeiner, G., Eberharter, V. 1991. The iron law of important articles. ***Southern Economic Journal***, 58: 317-328.

Horta, H., Sato, M., Yonezawa, A. 2011. Academic inbreeding: Exploring its characteristics and rationale in japanese universities using a qualitative perspective. ***Asia Pacific Education Review***, 12: 35-44.

Inanc, O., Tuncer, O. 2011. The effect of academic inbreeding on scientific effectiveness. ***Scientometrics***.

Jacob, B. A., Lefgren, L. 2011. The impact of nih postdoctoral training grants on scientific productivity. ***Research Policy***, 40: 864-874.

Johnston, R. 1994. Effects of resource concentration on research performance. ***Higher Education***, 28: 25-37.

Kneller, R. 2007. Prospective and retrospective evaluation systems in context: Insights from japan. In Whitley, R. & Glaser, J. (Eds.), ***Changing governance of the sciences: The advent of research evaluation systems***. Dordrecht, Netherlands.: Springer.

Laband, D. N., Tollison, R. D. 2003. Dry holes in economic research. ***Kyklos***, 56: 161-173.

Macroberts, M. H., Macroberts, B. R. 1996. Problems of citation analysis. ***Scientometrics***, 36: 435-444.

Martin, B. R. 2013. Whither research integrity? Plagiarism, self-plagiarism and coercive citation in an age of research assessment. ***Research Policy***, 42: 1005-1014.

Mcallister, P. R., Anderson, R. C., Narin, F. 1980. Comparison of peer and citation assessment of the influence of scientific journals. ***Journal of the American Society For Information Science***, 31: 147-152.

Merton, R. K. 1973. ***Sociology of science***. Chicago: University of Chicago Press.

Morichika, N., Shibayama, S. 2011. Inbreeding in japanese university laboratories., ***Japan Society for Science Policy and Research Management Annual Meeting.*** Yamaguchi Japan.

Nagaoka, S., Kondo, M., Flamm, K., Wessner, C. 2009. ***21st century innovation systems for japan and the united states: Lessons from a decade of change: Report of a symposium***. Washington, D.C.: The NATIONAL ACADEMIES PRESS.

Narin, F., Hamilton, K. S. 1996. Bibliometric performance measures. ***Scientometrics***, 36: 293-310.

Oswald, A. J. 2007. An examination of the reliability of prestigious scholarly journals: Evidence and implications for decision-makers. ***Economica***, 74: 21-31.

Ravetz, J. R. 1973. ***Scientific knowledge and its social problems***: Oxford University Press

Roach, M., Sauermann, H. 2010. A taste for science? Phd scientists' academic orientation and self-selection into research careers in industry. ***Research Policy***, 39: 422-434.

Salonius, A. 2008. ***Working in the lab: Social organization of research and training in biomedical research labs in canada and its relationship to research funding*** MCGILL UNIVERSITY, Quebec, Canada.

Scellato, G., Franzoni, C., Stephan, P. 2012. Mobile scientists and international networks, ***NBER Working Paper***, Vol. 18613.

Seglen, P. O. 1997. Why the impact factor of journals should not be used for evaluating research. ***British Medical Journal***, 314: 498-502.

Shibayama, S. 2011. Distribution of academic research funds: A case of japanese national research grant. ***Scientometrics***, 88: 43-60.

Shibayama, S. 2012. Conflict between entrepreneurship and open science, and the transition of scientific norms. ***Journal of Technology Transfer***, 37: 508–531.

Shibayama, S., Walsh, J. P., Baba, Y. 2012. Academic entrepreneurship and exchange of scientific resources: Material transfer in life sciences and materials science in japanese universities. ***American Sociological Review***, 77: 804-830.

Shibayama, S., Baba, Y., Walsh, J. P. 2013. Social organization of life science laboratories., ***American Sociological Association Annual Meeting***. New York NY.

Shimizu, H., Nirei, M., Maruyama, K. 2012. Management of science, serendipity, and research performance: Evidence from scientists' survey in the us and japan, ***Schumpeter Conference***. Brisbane, Australia.

Sousa, R. 2008. Research funding: Less should be more. ***Science***, 322: 1324-1325.

Stephan, P., Levin, S. 1992. ***Striking the mother lode in science: The importance of age, place, and time.*** New York: Oxford University Press.

Stephan, P. E. 2012. ***How economics shapes science***. Cambridge, MA: Harvard University Press.

Stokes, D. E. 1997. ***Pasteurs quadrant: Basic science and technological innovation*** Washington, D.C.: Brookings Institution Press.

Subramanian, A. M., Lim, K., Soh, P. H. 2013. When birds of a feather don't flock together: Different scientists and the roles they play in biotech r&d alliances. ***Research Policy***, 42: 595-612.

Wallace, M. L., Lariviere, V., Gingras, Y. 2009. Modeling a century of citation distributions. ***Journal of Informetrics***, 3: 296-303.

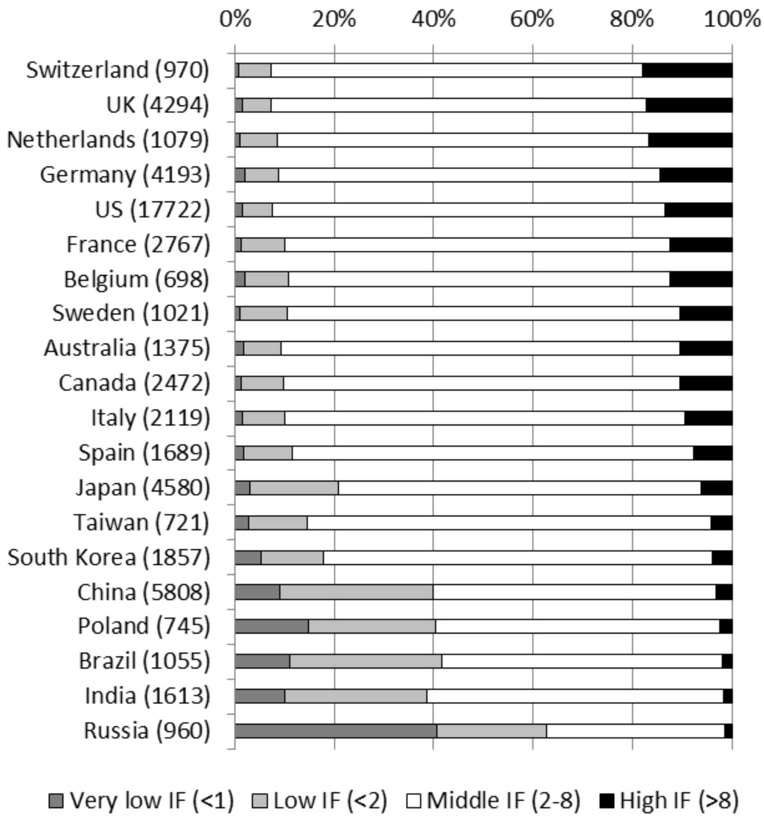
Walsh, J. P., Cohen, W. M., Cho, C. 2007. Where excludability matters: Material versus intellectual property in academic biomedical research. ***Research Policy***, 36: 1184-1203.

Walsh, J. P., Huang, H.-I. 2007. Research tool access in the age of the ip society: Results from a survey of japanese scientists. Washington, D.C.: American Association for the Advancement of Science.

Wilhite, A. W., Fong, E. A. 2012. Coercive citation in academic publishing. ***Science***, 335: 542-543.

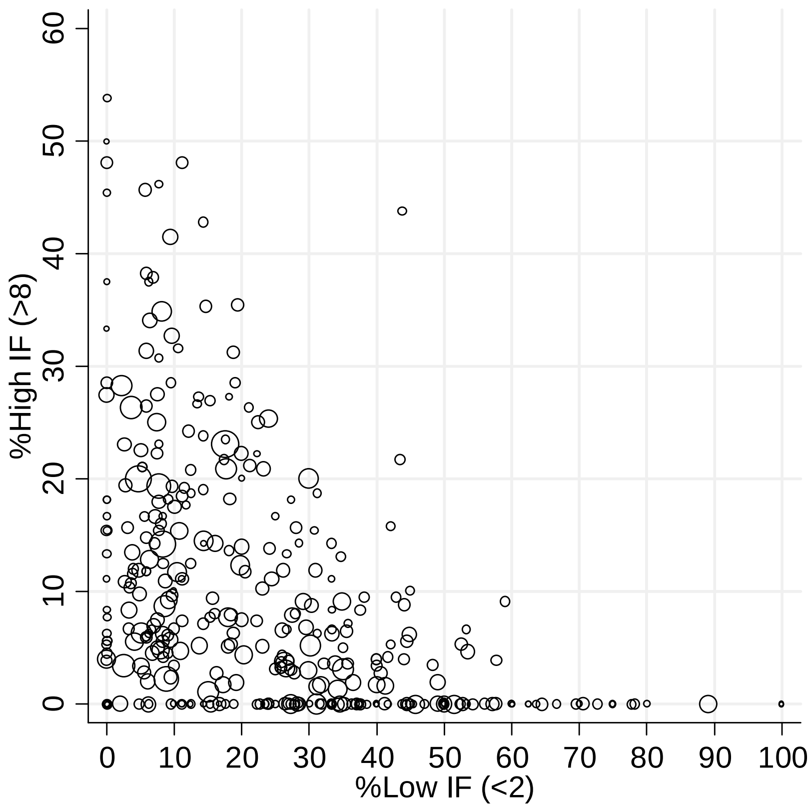
Ynalvez, M. A., Shrum, W. M. 2011. Professional networks, scientific collaboration, and publication productivity in resource-constrained research institutions in a developing country. ***Research Policy***, 40: 204-216.

Figure 1 Portfolio of Publication Quality by Country [a]




[a] The numbers in the parentheses are the number of articles. Top 20 countries are chosen based on the article count and sorted by the high-IF ratio. Thresholds of IFs follow the description in Ch.5. Publication data is obtained from WoS with the search criteria of publication year (PY) = 2010, subject category (WC) = "Biochemistry & Molecular Biology," and document type (DT) = article, letter, proceedings paper, or review. Then, each article is assigned with IF based on JCR and is linked to countries based on authors' address (AD).

Figure 2 Portfolio of Publication Impact at Individual Level [a]




[a] N = 352. The circle size represents the publication count of each respondent. Respondents who published five or fewer papers in 2006-2010 are omitted.

Table 1 Determinants of Publication Quality in Three Stages

| Key determinants | Stages of decision making | | | Examples in the Japanese context (Results from interviews and regression analyses) |
|---|---|---|---|---|
| | 1: Mission | 2: Project | 3: Publication | |
| Priority in multiple missions | x | x | x | • Student-authorship compromises publication quality for early graduation.<br>• Research orientation toward practical application decreases publication quality, but it increases quality if actually applicable to industrial needs.<br>• Industry coauthorship results in secrecy and in publication intended primarily for advertisement with compromised quality. |
| Norms on quality | | x | x | • International mobility facilitates normative assimilation; returnees from foreign research experience avoid publishing low-quality papers.<br>• Inbred academics avoid engaging in challenging projects leading to high-quality publication. |
| Capacity for research | | x | | • Input of research budget is essential for maintaining scientific production, but excessive budget facilitates low-quality publication.<br>• Input of human resources is also indispensable but too many members (PhD students) in a lab lead to low-quality publications for overcapacity. |

## Table 2 Descriptive Statistics (Individual Level) [a]

| | Variable | Mean | SD | Min | Max | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | %IF<1 | 9.64 | 14.30 | .00 | 100.00 | | | | | | | | | | | | | | | | | | |
| 2 | %IF<2 | 23.89 | 19.88 | .00 | 100.00 | ***.706*** | | | | | | | | | | | | | | | | | |
| 3 | %IF>8 | 9.53 | 11.27 | .00 | 53.85 | ***-.228*** | ***-.439*** | | | | | | | | | | | | | | | | |
| 4 | #Total pub | 32.76 | 25.13 | 5.00 | 165.00 | ***-.169*** | ***-.166*** | .070 | | | | | | | | | | | | | | | |
| 5 | #Total adjusted cite | 46.43 | 68.66 | .00 | 880.87 | ***-.189*** | ***-.291*** | ***.313*** | ***.644*** | | | | | | | | | | | | | | |
| 6 | #Adjusted cite before tenure | 2.60 | 4.58 | .00 | 45.24 | ***-.141*** | ***-.249*** | ***.335*** | .065 | ***.297*** | | | | | | | | | | | | | |
| 7 | Univ rank | 2.26 | 1.08 | 1.00 | 4.00 | -.085 | ***-.175*** | ***.195*** | ***.230*** | .132 | .083 | | | | | | | | | | | | |
| 8 | Female | .03 | .17 | .00 | 1.00 | .007 | -.004 | .000 | ***-.109*** | -.062 | -.026 | -.042 | | | | | | | | | | | |
| 9 | Time for research | 3.69 | 1.51 | 1.00 | 6.00 | ***-.152*** | ***-.208*** | ***.295*** | .043 | .109 | ***.127*** | .098 | .100 | | | | | | | | | | |
| 10 | Time for teaching | 1.70 | .95 | 1.00 | 6.00 | .074 | ***.137*** | -.038 | -.057 | -.077 | -.092 | ***-.174*** | -.029 | ***-.111*** | | | | | | | | | |
| 11 | Time for administration | 2.14 | 1.23 | 1.00 | 12.00 | ***.229*** | ***.254*** | ***-.133*** | -.086 | ***-.112*** | ***-.114*** | -.032 | -.020 | ***-.431*** | .098 | | | | | | | | |
| 12 | Applied research | 1.70 | .90 | 1.00 | 5.00 | .001 | ***.153*** | ***-.174*** | ***.111*** | -.071 | -.085 | ***-.143*** | -.049 | ***-.191*** | .079 | ***.111*** | | | | | | | |
| 13 | Industry collaboration | .55 | .50 | .00 | 1.00 | ***-.175*** | ***-.151*** | ***.112*** | ***.381*** | ***.271*** | .049 | ***.112*** | .029 | .075 | -.059 | -.031 | ***.177*** | | | | | | |
| 14 | #Years since first degree | 25.99 | 5.87 | 12.00 | 45.00 | .054 | ***.106*** | ***-.195*** | .084 | -.056 | ***-.272*** | .049 | -.046 | -.038 | -.056 | .056 | .084 | .079 | | | | | |
| 15 | Foreign experience | 3.65 | 1.54 | 1.00 | 6.00 | ***-.169*** | ***-.128*** | .063 | -.091 | ***-.103*** | -.093 | -.047 | .072 | .074 | .007 | -.014 | .046 | -.041 | ***.226*** | | | | |
| 16 | Inbred | .10 | .31 | .00 | 1.00 | ***.108*** | ***.112*** | ***-.137*** | .085 | .037 | -.044 | ***.209*** | -.060 | -.061 | .002 | .055 | -.018 | .018 | .080 | ***-.121*** | | | |
| 17 | #Staff | 4.31 | 2.64 | 1.00 | 20.00 | ***-.147*** | ***-.246*** | ***.261*** | ***.471*** | .354 | ***.172*** | ***.312*** | -.063 | ***.107*** | -.085 | -.083 | .004 | ***.234*** | .028 | .024 | .011 | | |
| 18 | #PhD/#staff | .77 | .73 | .00 | 4.33 | .028 | .066 | -.029 | .074 | ***.039*** | -.064 | .090 | .022 | -.050 | .004 | .080 | ***.115*** | -.009 | .041 | .040 | .047 | ***-.243*** | |
| 19 | Budget/#member | 4.08 | 3.84 | .28 | 37.50 | ***-.122*** | ***-.226*** | ***.159*** | .078 | .091 | .088 | .015 | -.051 | ***.204*** | .041 | ***-.154*** | -.008 | .043 | -.055 | .014 | -.032 | .074 | ***-.227*** |

[a] N = 365. Bold italic is significant ($p < .05$). Respondents who published five or fewer papers in 2006-2010 are omitted.

Table 3 Prediction of Publication Quality at Individual Level [a]

| | Model 1 %IF<1 | | Model 2 %IF<2 | | Model 3 %IF>8 | | Model 4 #Total pub | | Model 5 #Total adjusted cite | |
|---|---|---|---|---|---|---|---|---|---|---|
| #Adjusted cite before tenure | -.21 | (.17) | -.53 * | (.22) | .54 *** | (.12) | -.19 | (.26) | 3.19 *** | (.77) |
| Univ rank | -.61 | (.75) | -1.32 | (.97) | 1.14 * | (.53) | .69 | (1.15) | -4.39 | (3.40) |
| Female | 2.36 | (4.43) | .28 | (5.70) | .25 | (3.14) | -9.72 | (6.78) | -14.48 | (20.01) |
| Time for research | .01 | (.56) | .15 | (.71) | 1.22 ** | (.39) | -.60 | (.85) | .09 | (2.51) |
| Time for teaching | .47 | (.78) | 1.56 | (1.01) | .40 | (.55) | .07 | (1.20) | -.82 | (3.53) |
| Time for administration | 2.22 *** | (.66) | 2.79 ** | (.85) | .27 | (.47) | -1.60 | (1.01) | -2.57 | (2.97) |
| Applied research | .03 | (.87) | 3.06 ** | (1.12) | -1.60 ** | (.62) | .79 | (1.33) | -9.17 * | (3.92) |
| Industry collaboration | -4.76 ** | (1.54) | -4.71 * | (1.98) | 1.33 | (1.09) | 12.98 *** | (2.36) | 28.19 *** | (6.96) |
| #Years since first degree | .17 | (.13) | .30 † | (.17) | -.27 ** | (.09) | .27 | (.20) | .07 | (.60) |
| Foreign experience | -1.64 *** | (.49) | -1.90 ** | (.63) | .59 † | (.35) | -1.79 * | (.75) | -4.08 † | (2.22) |
| Inbred | 3.77 | (2.43) | 5.58 † | (3.12) | -4.47 ** | (1.72) | 3.72 | (3.71) | 8.12 | (10.97) |
| #Staff | -.28 | (.31) | -.94 * | (.40) | .65 ** | (.22) | 4.08 *** | (.48) | 8.03 *** | (1.41) |
| #PhD/#staff | -1.25 | (2.65) | -5.00 | (3.41) | 4.70 * | (1.88) | 9.63 * | (4.05) | 25.20 * | (11.96) |
| $(\#PhD/\#staff)^2$ | .19 | (.89) | 1.17 | (1.14) | -1.12 † | (.63) | -.97 | (1.36) | -2.69 | (4.00) |
| Budget/#member | -.88 * | (.39) | -2.36 *** | (.51) | 1.08 *** | (.28) | 1.40 * | (.60) | 3.82 * | (1.77) |
| $(Budget/\#member)^2$ | .02 † | (.01) | .06 ** | (.02) | -.03 *** | (.01) | -.03 | (.02) | -.10 | (.06) |
| F test | 4.06 *** | | 8.09 *** | | 9.72 *** | | 12.33 *** | | 7.85 *** | |
| Adjusted $R^2$ | .123 | | .244 | | .284 | | .341 | | .238 | |
| N | 352 | | 352 | | 352 | | 352 | | 352 | |

[a] Unstandardized coefficients and robust standard errors (parentheses). Two-tailed test. † p<0.10; * p<0.05; ** p<0.01;*** p<0.001. Ordinary least squares. Respondents who published five or fewer papers in 2006-2010 are omitted.

Table 4 Prediction of Publication Impact at Article Level [a]

(A) Base Model

| | Model 1 IF<1 | | Model 2 IF<2 | | Model 3 IF<8 | | Model 4 #Adjusted Cite | | Model 5 Impact Factor | |
|---|---|---|---|---|---|---|---|---|---|---|
| #Adjusted cite before tenure | -.074 * | (.029) | -.061 *** | (.016) | .044 ** | (.014) | .102 *** | (.010) | .093 *** | (.014) |
| Univ rank | -.088 | (.090) | -.061 | (.058) | .169 * | (.067) | .011 | (.042) | .163 ** | (.062) |
| Female | .161 | (.554) | -.077 | (.363) | .001 | (.443) | -.105 | (.302) | -.023 | (.418) |
| #Authors | -.002 | (.005) | .011 *** | (.001) | -.009 *** | (.002) | -.020 *** | (.001) | -.009 *** | (.001) |
| #Organizations | -.154 *** | (.028) | -.160 *** | (.016) | .092 *** | (.012) | .306 *** | (.008) | .145 *** | (.009) |
| Time for research | .002 | (.065) | .010 | (.042) | .126 ** | (.049) | .086 ** | (.030) | .099 * | (.044) |
| Time for teaching | .115 | (.091) | .077 | (.060) | .061 | (.071) | .051 | (.045) | -.013 | (.065) |
| Time for administration | .193 ** | (.074) | .138 ** | (.050) | .004 | (.068) | .031 | (.040) | -.015 | (.058) |
| Applied research | .059 | (.098) | .230 *** | (.064) | -.237 ** | (.080) | -.132 ** | (.047) | -.326 *** | (.069) |
| Industry coauthor | -.017 | (.161) | .073 | (.096) | .035 | (.114) | .272 * | (.110) | .255 † | (.136) |
| Student first author | -.156 | (.108) | -.174 * | (.068) | .044 | (.089) | .030 | (.082) | .044 | (.102) |
| #Years since first degree | .020 | (.016) | .011 | (.010) | -.026 * | (.012) | -.003 | (.007) | -.030 ** | (.011) |
| Foreign experience | -.179 ** | (.059) | -.106 ** | (.039) | .073 | (.045) | -.037 | (.029) | .132 ** | (.042) |
| Inbred | .408 | (.270) | .259 | (.180) | -.832 *** | (.238) | -.093 | (.131) | -.563 ** | (.194) |
| #Staff | -.070 † | (.036) | -.074 ** | (.023) | .079 ** | (.024) | .023 | (.015) | .135 *** | (.023) |
| #PhD/#staff | -.254 | (.310) | -.311 | (.199) | .826 ** | (.268) | .247 † | (.148) | .814 *** | (.215) |
| $(\#PhD/\#staff)^2$ | .018 | (.103) | .055 | (.066) | -.251 * | (.100) | -.009 | (.048) | -.191 ** | (.071) |
| Budget/#member | -.119 * | (.048) | -.155 *** | (.031) | .187 *** | (.051) | .045 * | (.023) | .211 *** | (.033) |
| $(Budget/\#member)^2$ | .003 † | (.002) | .004 *** | (.001) | -.007 * | (.003) | -.001 † | (.001) | -.005 *** | (.001) |
| | | | | | | | | | | |
| $\chi^2$ test | 105.57 *** | | 241.28 *** | | 199.00 *** | | 2230.60 *** | | 637.26 *** | |
| Observation | 11385 | | 11385 | | 11385 | | 11386 | | 11385 | |
| N | 366 | | 366 | | 366 | | 366 | | 366 | |

[a] Unstandardized coefficients and robust standard errors (parentheses). Two-tailed test. † p<0.10; * p<0.05; ** p<0.01;*** p<0.001. The random effects of academics are controlled for. Ordinary least squares in Models 4-5 in Table 2A, and logit regression in all other models. Only focal variables are presented in Tables B and C for parsimony.

(B) Effect of Industry Coauthorship

| | Model 1<br>IF<1 | | Model 2<br>IF<2 | | Model 3<br>IF<8 | | Model 4<br>#Adjusted Cite | |
|---|---|---|---|---|---|---|---|---|
| Industry coauthor | -.372 | (.237) | -.125 | (.149) | .272 | (.185) | .351 * | (.138) |
| Industry collab but not coauthor | -.383 * | (.188) | -.214 † | (.124) | .255 | (.156) | .093 | (.098) |

(C) Effect of Student First Authorship

| | Model 1<br>IF<1 | | Model 2<br>IF<2 | | Model 3<br>IF<8 | | Model 4<br>#Adjusted Cite | |
|---|---|---|---|---|---|---|---|---|
| Univ rank | -.056 | (.092) | -.057 | (.059) | .134 * | (.069) | .008 | (.045) |
| Student first author | .286 | (.268) | -.113 | (.178) | -.583 * | (.270) | -.024 | (.217) |
| Student first author x Univ rank | -.179 † | (.101) | -.024 | (.064) | .220 * | (.088) | .021 | (.077) |