Paper to be presented at the

DRUID Society Conference 2014, CBS, Copenhagen, June 16-18

Why Top Scientists Publish Junk Papers: Unveiling Hidden Rationales behind Scientific Publication with a Case Study of Japanese Life Sciences

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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.

Jelcodes:O31,O38

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

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Abstract

Modern science system relies on intense evaluation of scientific publication, in which scientific "impact" is highly emphasized, but the current system seems to overlook multifaceted nature of scientific publication. Drawing on in-depth survey of professors in the Japanese biology sector, this study aims to identify the determinants of high and low-impact publications, and in particular, to examine how academics' norms on low-impact publication are influenced under science system that gives strong emphasis on impact. First, the result suggests that though papers published in scientific journals are considered simply the output of science, they are, in fact, a collection of differently motivated products. Second, comparing sample of domestic academics and returnees from foreign research experience, we find that the latter group, who presumably experienced stronger pressure for impact, becomes unwilling to publish in low-impact journals, and this might imply a deviation from the open science norms.

Keywords

Scientific production; publication; impact factor; science policy; evaluation

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1. Introduction

The progress of academic science is crucially underpinned by the norm of open science, which prescribes that every scientific discovery should be reported without delay and shared among scientific community, so that the new knowledge is ready for verification and available as a basis for subsequent research (David, 1998; Merton, 1973). While academics have to forgo rights to their discoveries through publication, they are rewarded by recognition and esteem from their peer academics. This reward system remains indispensable, but modern science is also under stricter external control (Geuna and Martin, 2003; Hicks, 2012). That is, policymakers have increasingly emphasized the role of academic science in innovation and economic growth (Etzkowitz and Leydesdorff, 2000; Stephan, 2012) and implemented a range of evaluation systems as an attempt to boost scientific productivity. 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 system actually facilitates the progress of science. It is not difficult to find examples in which academics resort to rent-seeking behavior including misconducts and abuse of authorship to increase superficial productivity (e.g., Martin, 2013). Obvious misbehaviors set aside, ill-designed policy interventions could simply facilitate a large volume of mediocre publications. 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). Of course, science system has made attempts to incentivize quality rather than quantity. With a straightforward but probably oversimplistic premise that highly cited papers offer a good foundation for subsequent research (Cole and Cole, 1972), most evaluation systems somewhat incorporate citation indices. However, this has created another unintended consequence. Now academics are keen on receiving high citations, it is only natural that they prefer to publish papers in journals that are likely to invite many citations, so-called high-impact or prestigious journals. Though the quality of each paper varies even in high-impact journals (Oswald, 2007), publishing there of itself is regarded as a great scientific achievement. Evaluation systems explicitly or implicitly take into account 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 publication practice are well captured by Holub's criticism: "especially where a scientist publishes has become much more important than what he is publishing" (Holub et al., 1991).

Given such circumstances, however, it is intriguing to observe that academics keep publishing in low-impact journals. Figure 1 illustrates the proportion of publications in journals grouped by Impact Factors (IFs) in a field of life sciences. Not surprisingly, countries regarded as developed produce higher proportions of high-IF papers while less developed countries produce higher percentages of low-IF papers. Nevertheless, low-IF papers are universally produced. Interestingly, when focusing on the publication pattern at the individual level, we notice that many academics produce both high and low-IF papers (Figure 2; detail explained later). Considering that academics gain far greater rewards from high-IF publications (in terms both of peer reputation and of external evaluation), it looks paradoxical that authors of high-IF papers also publish low-IF papers. It looks even so, especially when the journal impact is reasonably correlated with the quality of papers,[1] which implies that academics capable of producing high-quality papers simultaneously produce mediocre papers. This has led us to question rationales behind such a publication pattern. To this inquiry, a few answers are conceivable. First, the volume of publications may be incentivized in a certain evaluation system, as in the example of the Australian funding system. Then, publishing low-IF papers can be cost-effective. The second possibility is that the audience of some journals may not be academics. Modern science is becoming heterogeneous, where social contribution is strongly encouraged (Etzkowitz and Leydesdorff, 2000). For example, publications intended for industrial practitioners may not be cited, and therefore, considered of low impact. The first goal of this paper is to further explore rationales behind scientific publication with organizational contexts taken into consideration.

On top of that, this paper also aims to examine academics' norms on low-impact publication. An important rationale for low-impact publication is that there are types of papers only accepted by low-impact journals but still are scientifically important; including replication studies, report on negative data, and research topics of narrow specificity. Some academics may publish these papers, believing their scientific relevance despite limited reward. This category is tricky from a policymaker's viewpoint because overemphasis on impact should discourage it, but a simple attempt to encourage it could end up compromising overall quality. The fact that some academics keep reporting this kind of papers is reassuring, which implies that academics are motivated not only by extrinsic factors (e.g., reputation, pecuniary rewards) but that some intrinsic sense of duty drives them to publish what may not be justly rewarded. However, prior literature finds that publication of this kind has been discouraged in the current regime (Dwan et al., 2008; Fanelli, 2010),

[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.

although this could be justified from a holistic productivity point of view. Nevertheless, the overemphasis on impact may have started to affect norms of scientists, and it may be the case that academics feel reluctant to publish in low-IF journals or even ashamed of doing so. Science is a probabilistic activity in that even excellent academics can end up non-novel results, and some academics may just scrap the results, instead of publishing in low-impact journals, even if additional cost for publication is negligible. Such a practice could contradict the basis of open science. Thus, we aim to examine how academics' values or norms on low-impact publication are influenced under the current "publish or perish" regime.

To these ends, this paper 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. Particularly for the second goal of this paper, we exploit a comparison between international returnees and domestic academics (who had no foreign research experience) to examine how the norms acquired during foreign stay are translated into publication patterns after returning to the home country.

This paper is structured as follows. Chapter 2 presents an overview of the literature on the reward system and publication practice. Chapter 3 outlines our data. Chapter 4 explores rationales behind scientific publication based on the literature review and our interviews. Chapter 5 offers econometric analyses based on questionnaire and bibliometric data, first to confirm the findings in Chapter 4 and second to investigate possible transformation of publication norms as a result of foreign stay. Finally, Chapter 6 discusses the results and summarizes policy implications.

2. Publication Norms and Practice in Modern Science

The progress of science essentially relies on publication of scientific papers in that new discoveries are made on the basis of prior findings in an accumulated fashion. Thus, academics are obliged to publish their findings to allow the scientific community to share them for verification and to use them for subsequent research (David, 2004). This system of open science has been functioning rather well -- academics are in fact highly motivated to publish -- though anti-normative or secretive behavior is not uncommon (Rosenberg, 1996; Walsh and Hong, 2003). Open science is essentially sustained by the reward system, in which first discoverer is disproportionately rewarded with peer recognition, but on top of that, modern science has implemented incentive mechanisms for publication. Policymakers and research organizations, with the aim of expediting scientific production, evaluate academics and allocate resources based on publication records (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 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, in the modern science, academics are forced to strive in the publish-or-perish regime (Hagstrom, 1974).

While this might be contributing to the progress of science, it has affected the practices of scientific publication in unintended manners. As mentioned above, academics resort sometimes to misconducts and more often to less obvious rent-seeking behaviors such as fragmentation of publication and abuse of authorship (e.g., Martin, 2013). Responding to the unprecedented needs for publication space, 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). When incentive mechanisms started to incorporate impact of publications, which tends to be measured by citation indices, academics responded simply by attempting to increase citations, whether or not it translates into quality. 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). Under strong emphasis on citation, academics obviously want to publish their papers in journals that are likely to invite many citations, and this demand has resulted in the ranking of journals based on impact. In most fields of science, some journal rankings are available. Among other ranking systems, Impact Factor (IF) is one of the most famous and frequently used. Highly-ranked journals attract more submissions, which raises the quality of papers accepted by those journals. In this spiral, journal impact has been substantiated and come to represent the impact of papers published in them (Gordon, 1984; Ravetz, 1973). Although the consensus on the ranking system differs by fields, journal impact is known as one of the most important decision criteria when academics choose which journal to send out their manuscripts to (Frank, 1994; Gordon, 1984), and journal impact is explicitly or implicitly taken into account in many evaluation systems. While the emphasis on publication impact or journal ranking may contribute to discouraging rent-seeking publications of mediocre quality, it is not without flaw. Obviously, any journal ranking has error or bias (e.g., Denrell and Liu, 2012). In addition, it is arguable whether high citation really means good contribution to science (Macroberts and Macroberts, 1996). In the same vein, rarely-cited papers and low-impact journals do not necessarily mean that they are useless. For example, journals or papers intended for practical application may not be much appreciated by scientific peer, which is likely to yield low citation and low ranking score.

More importantly, some types of scientific discoveries are of some scientific relevance but not well rewarded, perhaps unjustifiably poorly rewarded; such as replication studies and report on negative data. This category of scientific contribution may not produce breakthrough to scientific advancement but reinforces the basis of scientific knowledge. The Ortega hypothesis contends that it is the accumulation of these modest publications that really advances science. Quite straightforwardly, however, publication of this category is found underproduced in the current regime. For example, empirical studies in various scientific fields have shown that negative data is less likely to be published (Dwan et al., 2008; Fanelli, 2010). While prior literature has suggested that incentive mechanisms with excessive emphasis on impact cause under-report of this category, we suppose that they could also affect the norms of scientists. That is, under the strong emphasis on publication impact, some scientists or scientific communities might have established a belief, for example, that publishing papers only acceptable by low-impact journals does not deserve efforts of prominent academics, or that publishing non-novel results is a waste of resources (e.g., for peer review). In fact, the opposite of Ortega hypothesis -- that only a tiny part of scientific discoveries contributes to the progress of science -- seems much more popular (Cole and Cole, 1972). For example, with a sample of economists, Hamermesh and Pfann (2012) imply that publishing many mediocre papers is looked down upon in the American academic culture. While this standpoint is understandable and probably adequate, they could compromise the basis of open science if going too far. The novelty or impact of research outcome is often probabilistic in that well-designed research can end up in mediocre results. In such a situation, some academics may just publish them in low-impact journals believing it will do good to science, but others may scrap them believing otherwise. In this way, academics could have different attitudes on publishing low-impact papers or publishing in low-impact journals. We hypothesize that this attitude should be affected under the current regime; more specifically, that emphasis on publication impact develops a norm against low-impact publication.

3. Data

This study aims first to explore multifaceted rationales behind publication and second to investigate how academics' norms on low-impact publication changes under incentive systems emphasizing publication impact. To these ends, 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 can be hidden in strong incentive systems. 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-impact publications than other developed nations (Figure 1). The field of biology is chosen because the standard of journal impact has attained a high consensus in the field (Mcallister et al., 1980).

As for the second objective, evaluating changes in norms is tricky because academics are under the influence of certain incentive mechanisms. To address this issue, we focus on a single country of Japan, where external incentive mechanism is uniform and rather weak, and we exploit returnees from foreign countries (mostly the US) whose norms can be transformed under presumably stronger emphasis on publication impact. That is, if they stayed abroad long enough, acquired the norms in the destination country, and returned home with them, we should be able to observe distinct publication patterns between domestic and internationalized academics, with the direct effect of incentive mechanisms being controlled.

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. Based on the interviews, we further 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.[2] 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.[3] After re-examining their research fields and affiliations with public information, we

[2] In the Japanese chair system, associate and assistant professors may not be a PI but be supervised by another full professor.
[3] 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).

chose 900 PIs in 56 universities as a final sample.[4] We designed our survey instrument based on the interviews. We mailed the survey and collected 400 responses (response rate = 44%).[5] For the 400 respondents, we collected CV data from a governmental database[6] and publication data of approximately 40,000 articles that the respondents authored till 2010 from Web of Science (WoS). We also obtained the Impact Factor (IF) data from Journal Citation Report (JCR).

4. Publication Practice in the Japanese Context

Drawing on interview results and literature review, this chapter explores how academics behave in scientific publication under specific organizational and policy contexts of Japan. Our interviewees suggested that publication impact can be affected by roughly three factors. 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-impact research while others not. Such a choice of portfolio is importantly affected by research capacity, which substantially differs between laboratories under increasingly biased resource allocation. Third, academics can adopt different practices 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 practices seem to be learned through academics' career. In what follows, we discuss each of these factors: 1) priority in multiple missions, 2) capacity for research, and 3) academic's career.

4.1. Priority in multiple missions

The mission of academic organization has been becoming diverse in history (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

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[4] 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.

[5] 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 ($p > 0.1$).

[6] http://read.jst.go.jp/

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. With this regard, our interviewees consistently referred to two factors.

First, our interviewees suggested that the educational mission can be an important source of by-product publications, where academics do not really care about scientific impact. 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, an obvious policy trend in Japan, as in other many countries, is academic entrepreneurship (Etzkowitz and Leydesdorff, 2000; Nagaoka et al., 2009). Many academics have participated in these activities, and their focus of research has shifted from basic toward applied areas. 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.

On the other hand, the trend can crowd out motivation to achieve scientific excellence. 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 impact.

4.2. 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 for 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 recently 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 recent reforms, 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). 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. A possibly wasteful but likely 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. Biological 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. An interviewee 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.

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:

> 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 the productivity of biology research should depend on budgetary input (e.g., Jacob and Lefgren, 2011), we suppose that 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. 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.

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

4.3. Academic's Career

At large, most of our interviewees recognized that the Japanese system has been becoming impact-oriented. 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. 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 publication impact.

In terms of career development, the Japanese science system used to be, and still is partly, characterized by permanent employment and a high rate of inbreeding (Horta et al., 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 could either stabilize the research conditions or give academics room for slack. Our interviewees suggested that stability as well as slack seems to affect publication impact 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.

Such negative effects of inbreeding may be addressed by 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-impact 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' norms of publication impact or quality standard. With a sample of American economists, Hamermesh and Pfann (2012) suggest that publication count could have a negative effect on reputation in the US, which is clearly different at least from the pre-reform Japanese system. Thus, the norms on publication impact seem to be shaped under 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 low IF 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 impact and accordingly encourage research and publication strategies with a stronger orientation for impact.

5. Regression Analysis of Publication Impact

5.1. Analytical Approach

In this chapter, we use a questionnaire and bibliometric data, first, to confirm the findings in the previous chapter (Ch.5.3), and second to further examine the norms on low-impact publications (Ch.5.4). We primarily draw on the portfolio of publication impact at the individual level. We collected scientific papers published by individual academics in a certain period and analyzed the distribution of impacts among the collection of publications. As a measure of impact, we use the Impact Factors (IFs). IF is considered as a measure of quality or prestige at the journal level.[7] 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 evaluation 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. Thus, we believe that academics' choice of journals in terms of IFs well reflects their motives and is substantially affected by policy and organizational contexts. 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 published papers are accepted by the journals to which they are first submitted. That is, authors recognize the impact of their own papers and submit them to journals of suitable IFs.

In order to disentangle the determinants of high and low-impact publication, we categorize journal classes and investigate the explanatory factors for publication in each class. Based on our interviews, we categorize three journal classes; low impact (IF<2), middle impact (IF=2-8), and high impact (IF>8). Our interviewees suggested an intuitive threshold, saying that "IF around one 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."[8] We set a threshold of IF<2 as low impact. Interviewees also suggested that IF=7-8 or above is regarded as high impact, so we set IF>8 as another threshold. Among the 12,000 articles that our respondents published from 2006 to 2010, 21% are low, 69% are middle, and 10% high-impact publications.[9]

5.2. Measurement

5.2.1. Dependent variables

We run regressions at the individual level, and additionally, at the article level. As article-level measures, we prepared dummy variables of IF<2 and IF>8 as well as raw IF values. As individual-level measures, we computed the percentage of each IF class: %IF<2 and %IF>8 for all papers published by each

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[7] 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/).

[8] 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.

[9] 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 19%, 74%, and 8% from low to high impact (Appendix 1).

respondent in 2006-2010. We also computed per-member publication count (publication count divided by the number of lab members). Figure 2 illustrates the impact-based portfolio of publication by plotting %IF<2 vs. %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.[10] Since regression results with non-adjusted and adjusted measures are qualitatively similar, we primarily report results with non-adjusted measures.

5.2.2. Independent variables

At the article level, we prepared several measures. Based on WoS data, we identified industry partners in the author list of each paper, and we prepared a dummy variable, assigning one if at least one author was from industry (industry coauthor). Similarly, we prepared a dummy variable assigning one if at least one author was affiliated to non-Japanese addresses (international coauthor). To examine the possibility of by-product publication due to student training, we identified PhD students included in the author list of each paper.[11] 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). We control for types of journals. Following Tijssen (2010), which specifies industry-oriented journals and clinical-oriented journals based on the author affiliations (the former includes firms and the latter includes hospitals), we prepared dummy variables of industrial journal and clinical journal.[12] We also control for domestic publisher, assigning one if a journal's publisher is in Japan, because domestic journals tend to have lower IF for smaller audience. We also control for the number of authors (#author) and the number of author organizations (#organization).

At the individual level, 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). We also

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[10] 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 some confidence in the interpretation of our results.

[11] 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.

[12] One journal can be both industrial and clinical.

measured inbreeding with a dummy variable, assigning one if respondents earned their PhD in the current laboratory and zero otherwise (inbred). We measured PIs' generation by the number of years since the first degree. 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 use the summation of these numbers as a lab size measure (#member). We asked the total research budget in the year of 2010. To 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). 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. We control for institutional capital by university rank based on the amount of competitive funding with a four-point scale: 4 = 1^{st} or 2^{nd}, 3 = 3^{rd}-7^{th}, 2 = 8^{th}-20^{th}, and 1 = 21^{st} or below (univ rank).[13] We also control for gender (female) and medical doctor (MD). Table 2 presents the descriptive statistics at the individual level.

5.3. Determinants of publication impact

Table 2 presents the regression results for the article-level analyses, where the fixed effects of individual academics are controlled for. Table 3 shows the results for individual-level analyses. Table 2 reveals some significant effects of control variables. First, domestic publisher is significantly associated with low-IF journal (Model 2: b = 3.502, p < .001). Industrial journals are of higher IF (Model 1: b = 1.168, p < .001), while clinical journals are of lower IF (Model 1: b = -1.245, p < .001). International coauthorship is associated with high-IF journal (Model 3: b = .560, p < .001). Since these factors depend on authors' publication strategies, we further investigate their role in Ch.5.4.

5.3.1. Multiple missions

First, we examined the effect of student training in Table 2. When a variable of student first author alone is introduced, the effect was unclear (result not shown). Since the ability of PhD students can significantly differ with university ranks (Shibayama et al., 2013), we incorporated the interaction term between student author and university rank. The result suggests that high-impact publication is facilitated when a paper is first-authored by students in high-ranked universities. However, in low-ranked universities,

[13] 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.

student-led papers are of significantly lower-impact.[14] 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.

Second, we examined the effect of entrepreneurial orientation. As mentioned above, journals intended for industrial audience have higher IFs. To examine the effect of industry collaboration respectively for industrial journals and for non-industrial journals, we introduced an interaction term in Table 2. Models 2 and 3 show significant interaction effect, which suggests that industrial coauthorship is associated with lower IFs for industrial journals whereas it is associated with higher IFs for non-industrial (i.e., basic) journals.[15] The former result is consistent with the argument that industry collaboration might compromise quality due to secrecy or that such papers are published more for advertisement than for scientific progress. On the other hand, the latter agrees with the argument of Pasteur scientists (Stokes, 1997).

Additionally, we examine the effect of time allocation at the individual level (Table 3A).[16] Time for research has a significantly positive effect on high-IF publication (Model 2: $b = 1.67$, $p < .001$) but not on low-IF publication (Models 1). 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-impact research. Since time for research does not increase publication count but rather decreases it (Model 3), academics with greater research time seem to concentrate on high-impact research but not to engage in many projects. Time for administration significantly lowers impact (Model 1: $b = 2.75$, $p < .01$). Since this occurs after time for research is controlled, administrative effort might crowd out the motivation to achieve scientific excellence. Time for teaching has no significant effect.

5.3.2. Research capacity

The effect of research capacity seems quite straightforward in Table 3A, which suggests that greater human resource and budget increase the impact of publications. These results are consistent with the assumption that biology research is resource- and labor-intensive (Jacob and Lefgren, 2011; Johnston, 1994). For a closer inspection, we disentangle the factor of human resource input into two measures; the number of staff researchers (e.g., professors, postdocs) and the number of per-staff students, and we also introduce quadratic terms of these resource factors (Table 3B). The quadratic term of per-staff students shows a negative

[14] The effect of student first author on high-IF publication is -.260 (= -.514 + 1 * .254) in bottom-ranked universities (univ rank = 1) and +.494 (= -.514 + 4 * .254) in top-ranked universities (univ rank = 4).

[15] The effect of industrial coauthorship on low-IF publication is -.233 (=.393 - .626) for industrial journals and +.393 for non-industrial journals.

[16] The same models are run for respondents with at least one high-IF publication in Appendix 2, which shows qualitative similar results.

coefficient on high-impact publication (Model 2: $b = -1.17$, $p < .1$). Thus, students may be a source of high-impact research, but this effect diminishes 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 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 IF (Model 1: $b = .05$, $p < .01$; Model 2: $b = -.03$, $p < .001$). Thus, excessive budget compromises impact. 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 3), a larger budget linearly yields more papers, but their quality starts to decline at some point.

5.3.3. Academic's career

As for the career factors, Table 3A shows that number of years since the first degree is positively associated with low-IF publication (Model 1: $b = .48$, $p < .01$) and negatively with high-IF publication (Model 2: $b = -.42$, $p < .001$). This is consistent with the observation that younger generations are keener on impact than older generations. In addition, inbreeding shows a negative effect on high-IF publication (Model 2: $b = -5.04$, $p < .01$) and a positive effect on low-IF publication (Model 1: $b = 6.39$, $p < .05$). The strongly negative effect on high-IF publication may imply that inbred academics tend not to engage in challenging and novel subjects.

Finally, foreign experience shows a negative effect on low-IF publications (Model 1: $b = -1.66$, $p < .01$) but insignificant effect on high-IF publications. It also decreases publication count (Model 3: $b = -.34$, $p < .05$). Therefore, returnees from foreign experience may not only avoid low-impact research but also choose not to submit low-impact papers for publication. In addition, we dichotomize the variable with different thresholds (the original measure is six-point scaled) and find that foreign experience longer than one year changes the portfolio of publication impact. That is, too short a stay may not affect academics' norms but that a one-year or longer stay facilitates normative assimilation. These possibilities are further discussed in the following section.

5.4. Norms on Low-Impact Publication

In this section, we further investigate the norms on low-impact publication, by comparing returnees from foreign research experience and those without such experience. Before regression analyses, Figure 3 presents a result from questionnaires on subjective opinions about low-impact publication. One question refers to the impact of papers (Figure 3A), while another refers to the impact of journals (Figure 3B). For the former, the difference between academics with foreign experience and those without such experience is insignificant (T-test of mean: 3.29 vs. 3.35, $p > .1$). For the latter, however, the difference is significant (2.88 s. 2.46, $p < .01$). These results suggest that returnees are reluctant to publish in high-IF journals but they are not necessarily reluctant to publish low-impact papers.

Informed by this result, in the following analyses, we attempt to distinguish publication in low-IF journals and publishing low-impact papers. To this end, we prepared another dependent variable based on zero-cited papers. We collected citation information for our respondents' articles and identified zero-cited articles with two-year time window (i.e., if an article receives no citation within two year after publication, it is regarded as zero-cited). Zero-citation means that the article is not cited even by its authors themselves, and that it does lead to subsequent research even inside the lab, which implies a specific form of low impact.[17]

In this section, we aim to clarify the difference in publication patterns caused by foreign stay. To this end, we computed the same measurements used as dependent variables also for the period within five years of graduation and controlled for them; i.e., we essentially attempt to see the difference between before and after the foreign stay. Thus, we dropped from the following analyses respondents for whom such measurements cannot be prepared (e.g., those who earned PhD degrees in foreign universities).

Table 4A shows the result of the base model. The result suggests that foreign experience reduced low-IF publication (Model 1: $b = -1.63$, $p < .05$) as expected, but that the effect on zero-cited publication is insignificant (Model 3: $b = -.57$, $p >.1$). This result is consistent with the finding from subjective opinions (Figure 3).

Next, because the article-level analysis (Table 2) shows that choice of journal types (clinical, industrial, and domestic) and coauthorship affects the journal impact, we examine the mediating effect of these factors. Table 4B regresses percentage of industrial journals, clinical journals, academic journals (i.e., neither industrial nor clinical), domestic journals, and internationally-coauthored journals on the same set of independent variables. The result shows that foreign stay decreases the percentage of academic journals (Model 3: $b = -2.30$, $p < .05$), suggesting that returnees tend to become application oriented. Foreign stay also decreases the percentage of domestic journals (Model 4: $b = -.96$, $p < .1$), which suggests that returnees are less engaged in domestic scientific communication. Finally, international coauthorship is increased (Model 5: $b = 1.77$, $p < .01$) probably for networking effect. Next, we included these three variables as independent variables in Table 4C. The result shows that the effect of foreign experience is reduced by academic journals and domestic journals, suggesting that the shift of journal types is the part of reasons low-IF publication declines

[17] Zero-citation can be caused by other reasons than impact (Macroberts and Macroberts, 2010).

after foreign experience.

To further investigate these results, we run difference model (Table 4D), in which we take the difference of each variable between two periods (five years after graduation and recent five years) and use a dummy variable for the foreign stay (assigning one if a respondent stayed abroad for one year or more). Publication in domestic journals is positively associated with low-IF publications (Model 2: $b = 38.04$, $p < .001$) and zero-cited publications (Model 4: $b = 13.77$, $p < .1$), and international coauthorship reduces low-IF publications (Model 2: $b = -11.36$, $p < .1$). These effects of mediating variables are slightly different from the result in Table 4C. After controlling for mediating effects, foreign experience is still significantly effective on low-IF publications (Model 2: $b = -10.03$, $p < .05$) while it is insignificant for zero-cited publications (Model 4: $b = -7.39$, $p > .1$). These results imply that foreign experience affects where to publish rather than what to publish.

Finally, we examine how the decrease in the percentage of low-IF publications is realized, by analyzing the effect of foreign stay on publication count (Table 5). The result suggests that foreign experience reduces publication count in low-IF journals (Model 2: $b = -.11$, $p < .05$). However, this does not lead to an increase in publication count in high-IF journals (Model 3). Similarly, foreign experience slightly reduces the count of zero-cited publications (Model 4: $b = -.04$, $p < .05$), but this does not increase the count of cited publications (Model 5). These results imply that foreign experience does not induce a shift of effort from low-impact publications to higher-impact publications, but that foreign experience discourages low-impact publications. That is, returnees may be more likely to scrap mediocre papers without publication, consistent with one of the interviewee's comment.

6. Discussion

Modern science is characterized by the doctrine of publish or perish with a strong emphasis on evaluation of scientific publication (Fanelli, 2010), but its effect 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 high-impact papers are found to produce also low-impact papers even under impact-oriented evaluation systems. To explicate this seemingly paradoxical behavior and to explore the rationales of scientific production, this study examines the impact-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 first reveals some determinants of low and high-impact 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. This study offers three implications for science policy. First, the result suggests 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. Second, the result indicates that excessive resource input can actually compromise impact, despite that policymakers often emphasize concentration of resources on productive academics. 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. These results call for rethinking the evaluation systems in modern science. Third, the result suggests that publication practice substantially differ with academics' career process such as inbreeding and mobility.

On top of these findings, this study aims to examine how academics' norms on low-impact publication can be influenced in the current regime. To this end, we drew on comparison between international returnees and domestic academics and examine how the norms acquired during foreign stay are translated into publication patterns after returning to the home country. The result implies that returnees from foreign experience (mostly from the US) tend to demonstrate peculiar norms compared to domestic academics. That is, returnees tend to show a negative attitude about publishing in low-IF journals though they show willingness to publish low-impact papers. In fact, returnees publish lower rates of papers in low-IF journals than domestic academics, but the effect on low-impact (zero-cited) papers is not significant. These results may imply that returnees pay a greater attention to publication destination, but not to publication contents, after foreign experience. In addition, results suggest that lower percentage of low-IF publications seems achieved not by shifting the effort to higher-IF publication, but by simply reducing low-IF publications. That is, returnees may tend to scrap papers that are rejected or likely to be rejected by high-impact journals. 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-IF journals may offer a weaker scientific contribution, on average, this does not mean that they are useless. Thus, the observed reluctance to publish in low-IF journals can contradict the full disclosure of open science.

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 impact 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).

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.

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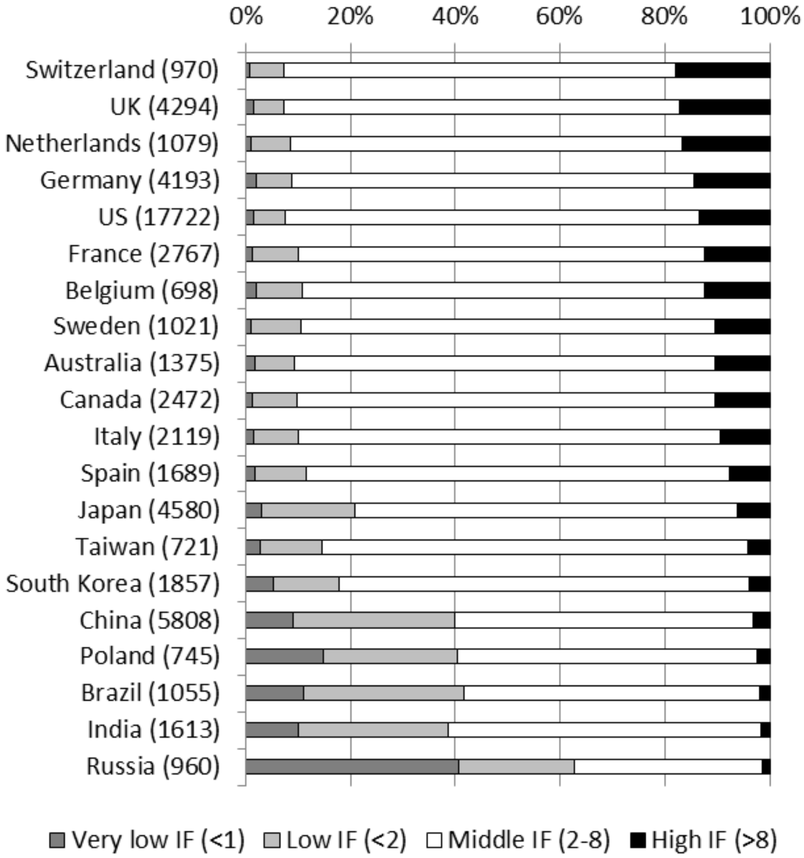
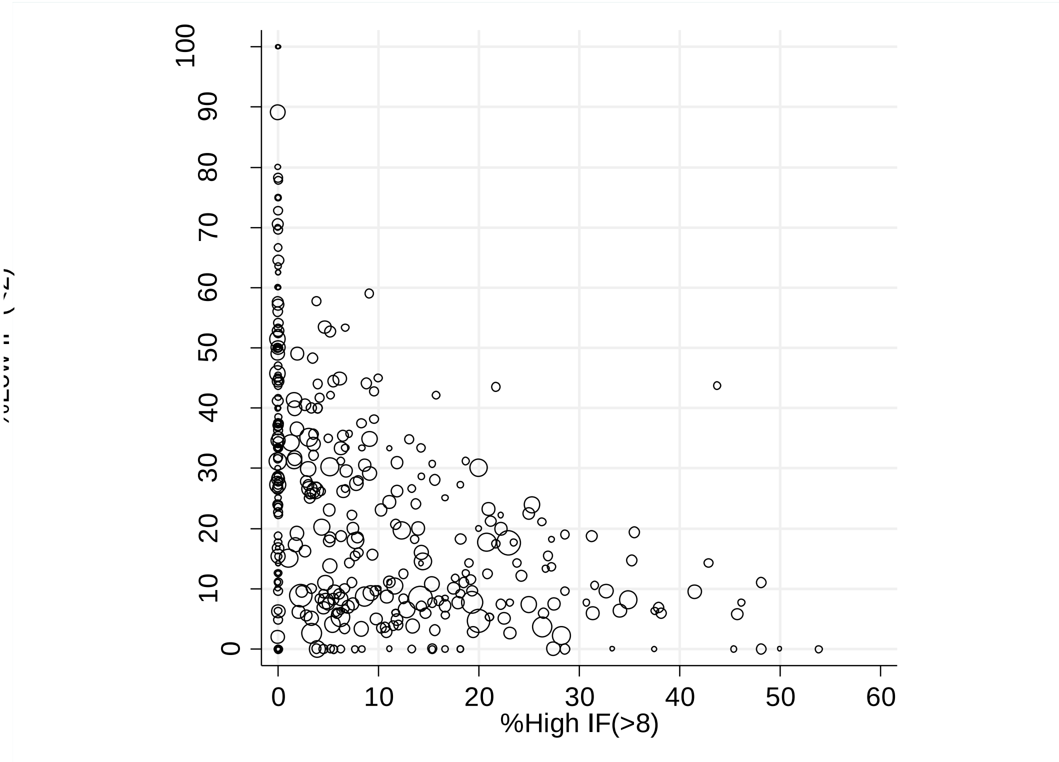
Figure 1 Portfolio of Publication Impact by Country [a]



[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).

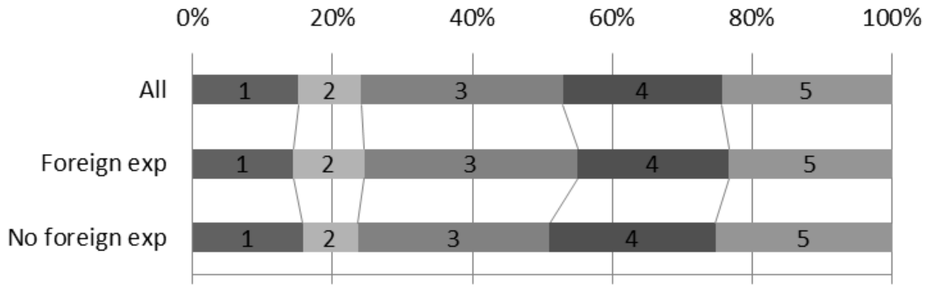
Figure 2 Portfolio of Publication Impact at Individual Level [a]



[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.

Figure 3 Opinion about Low-Impact Publication

(A) “Scientists should publish all the results even if they lack novelty.” (1: disagree – 5: agree)



(B) “Scientists should avoid publishing in journals that are rarely read because it is a waste of resources.” (1: disagree – 5: agree)

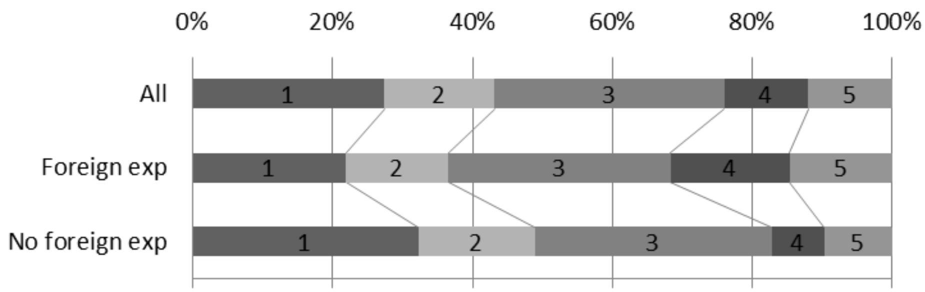


Table 1 Descriptive Statistics [a]

	Variable	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	%IF<2	23.89	19.88	.00	100.00																			
2	%IF>8	9.53	11.27	.00	53.85	**-.439**																		
3	%0-cited	9.71	10.29	.00	100.00	**.552**	**-.305**																	
4	#Pub/member	5.28	4.31	.60	48.00	.028	**-.131**	-.015																
5	Univ rank	2.26	1.08	1.00	4.00	**-.175**	**.195**	-.090	**-.100**															
6	Medical doctor	.17	.37	.00	1.00	**-.210**	**.211**	-.097	-.014	-.005														
7	Female	.03	.17	.00	1.00	-.004	.000	-.003	-.080	-.042	.050													
8	#Years since first degree	26.02	5.90	12.00	45.00	**.119**	**-.209**	.087	.071	.051	.091	-.047												
9	Inbred	.10	.31	.00	1.00	**.112**	**-.137**	**.145**	.050	**.209**	-.033	-.060	.078											
10	Foreign experience	3.64	1.54	1.00	6.00	**-.135**	.067	**-.105**	**-.108**	-.040	**.133**	.073	**.226**	**-.119**										
11	Time for research	3.69	1.51	1.00	6.00	**-.208**	**.295**	**-.181**	-.055	.098	.067	**.100**	-.049	-.061	.078									
12	Time for teaching	1.70	.95	1.00	6.00	**.137**	-.038	**.122**	.078	**-.174**	.000	-.029	-.065	.002	.006	**-.111**								
13	Time for administration	2.14	1.23	1.00	12.00	**.254**	**-.133**	**.186**	-.078	-.032	-.059	-.020	.067	.055	-.011	**-.431**	.098							
14	#Member	7.16	4.26	1.00	38.00	**-.220**	**.275**	**-.113**	**-.273**	**.355**	**.222**	-.078	.042	.049	.027	.076	-.081	-.028						
15	Budget/#member (JPY(M))	4.08	3.84	.28	37.50	**-.226**	**.159**	**-.141**	**.210**	.015	.062	-.051	-.060	-.032	.015	**.204**	.041	**-.154**	-.048					
16	%Industrial journal	57.80	28.73	.00	100.00	**-.265**	**.201**	**-.189**	.036	-.002	.025	-.062	-.045	-.093	.064	**.115**	.032	-.074	.093	**.128**				
17	%Clinical journal	40.79	31.49	.00	100.00	**-.450**	**.225**	**-.237**	-.066	-.011	**.428**	-.074	-.013	-.056	**.163**	**.175**	-.066	**-.160**	**.206**	.096	**.183**			
18	%Academic journal	26.96	30.11	.00	100.00	**.405**	**-.250**	**.265**	-.029	.049	**-.260**	.079	.039	.095	**-.138**	**-.174**	-.003	**.144**	**-.179**	**-.147**	**-.806**	**-.620**		
19	%Domestic journal	17.43	16.59	.00	80.00	**.540**	**-.367**	**.307**	.000	-.096	**-.237**	-.033	.057	.048	**-.130**	**-.165**	.080	**.164**	**-.209**	**-.206**	**-.242**	**-.449**	**.409**	
20	%Int'l coauthorship	23.60	17.94	.00	100.00	.004	**.180**	-.073	.045	-.061	.009	-.002	.017	.082	**.213**	.013	.031	-.004	.037	-.042	**-.181**	.016	**.136**	**-.126**

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

Table 2 Prediction of Publication Impact at Article Level [a]

	Model 1 Impact Factor		Model 2 Dummy IF<2		Model 3 Dummy IF>8	
#Authors	-.024 ***	(.002)	.007 **	(.003)	-.013 ***	(.002)
#Organizations	.263 ***	(.016)	-.127 ***	(.025)	.127 ***	(.016)
Domestic publisher	-2.606 ***	(.148)	3.502 ***	(.115)	-16.864	(394.191)
Industrial journal	1.168 ***	(.116)	-.599 ***	(.107)	1.237 ***	(.111)
Clinical journal	-1.245 ***	(.122)	.099	(.120)	-.595 ***	(.097)
Student 1st author	-.771 *	(.336)	-.418	(.291)	-.514	(.338)
Industry coauthor	-.070	(.296)	-.384	(.265)	.393	(.271)
International coauthor	.897 ***	(.120)	.040	(.114)	.560 ***	(.094)
Student 1st author x Univ rank	.358 **	(.118)	.043	(.103)	.254 *	(.110)
Industrial journal x Industry coauthor	.304	(.345)	.865 **	(.307)	-.626 *	(.305)
F/Chi squared test	101.317 ***		1460.371 ***		547.108 ***	
Observation	7941		6695		6098	
N	377		277		237	

[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 regression with fixed-effects in Model 1. Logit regression with fixed-effects in Models 2-3. In Models 2-3, some observations are dropped for lack of variation in the dependent variable.

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

(A) Base model

	Model 1 %IF<2		Model 2 %IF>8		Model 3 #Pub/#member	
Univ rank	-2.38 *	(.96)	1.59 **	(.54)	-.06	(.22)
MD	-8.48 **	(2.61)	4.97 ***	(1.45)	.51	(.59)
Female	1.28	(5.78)	-.95	(3.23)	-1.68	(1.32)
#Years since first degree	.48 **	(.16)	-.42 ***	(.09)	.09 *	(.04)
Inbred	6.39 *	(3.15)	-5.04 **	(1.76)	.67	(.72)
Foreign experience	-1.66 **	(.64)	.39	(.36)	-.34 *	(.15)
Time for research	-.45	(.71)	1.67 ***	(.39)	-.26	(.16)
Time for teaching	1.92 †	(1.01)	.18	(.56)	.25	(.23)
Time for administration	2.75 **	(.84)	.18	(.47)	-.39 *	(.19)
#Member	-.69 **	(.24)	.51 ***	(.14)	-.27 ***	(.06)
Budget/#member	-.96 ***	(.25)	.28 *	(.14)	.23 ***	(.06)
F test	10.07 ***		11.44 ***		6.16 ***	
Adjusted R^2	.217		.242		.137	
N	360		360		360	

(B) Effect of research capacity

	Model 1 %IF<2		Model 2 %IF>8		Model 3 #Pub/#member	
Univ rank	-2.14 *	(.95)	1.49 **	(.53)	-.04	(.22)
MD	-8.08 **	(2.59)	4.90 ***	(1.44)	.41	(.59)
Female	.99	(5.72)	-.76	(3.19)	-1.81	(1.31)
#Years since first degree	.46 **	(.16)	-.41 ***	(.09)	.09 *	(.04)
Inbred	5.75 †	(3.13)	-4.58 **	(1.75)	.51	(.72)
Foreign experience	-1.64 *	(.63)	.38	(.35)	-.34 *	(.15)
Time for research	-.33	(.70)	1.59 ***	(.39)	-.25	(.16)
Time for teaching	1.86 †	(1.00)	.21	(.56)	.24	(.23)
Time for administration	2.65 **	(.84)	.23	(.47)	-.38 *	(.19)
#Staff	-.89 *	(.40)	.60 **	(.22)	-.44 ***	(.09)
#Student/#Staff	-5.14	(3.35)	4.50 *	(1.86)	-2.56 ***	(.76)
$(\#Student/\#staff)^2$	1.40	(1.12)	-1.17 †	(.63)	.48 †	(.26)
Budget/#member	-2.32 ***	(.50)	1.14 ***	(.28)	.25 *	(.11)
$(Budget/\#member)^2$	.05 **	(.02)	-.03 ***	(.01)	.00	(.00)
F test	8.88 ***		10.09 ***		5.71 ***	
Adjusted R^2	.235		.262		.155	
N	360		360		360	

[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 by Foreign Experience [a]

(A) Base Model

	Model 1		Model 2		Model 3		Model 4	
	%IF<2		%IF>8		%0-cited		#Pub/#member	
DV (5 year after graduation)	.12 **	(.04)	.12 **	(.05)	-.01	(.02)	.13 *	(.05)
Univ rank	-1.82	(1.13)	1.57 *	(.69)	-.32	(.58)	-.25	(.23)
MD	-6.53 *	(3.04)	3.69 *	(1.87)	-1.52	(1.56)	-.63	(.61)
Female	4.58	(7.16)	-3.23	(4.40)	3.53	(3.71)	-1.42	(1.43)
#Years since first degree	.44 *	(.20)	-.45 ***	(.13)	.08	(.11)	.04	(.04)
Inbred	4.79	(3.43)	-4.54 *	(2.11)	2.75	(1.75)	1.07	(.68)
Time for research	.09	(.87)	1.40 **	(.53)	-.07	(.44)	-.26	(.17)
Time for teaching	1.45	(1.21)	.60	(.74)	.81	(.62)	.06	(.24)
Time for administration	3.02 *	(1.28)	.87	(.79)	1.15 †	(.66)	-.45 †	(.26)
#Member	-.81 **	(.29)	.52 **	(.18)	-.17	(.15)	-.18 **	(.06)
Budget/#member	-.75 **	(.27)	.16	(.16)	-.19	(.14)	.19 ***	(.05)
Foreign experience	-1.63 *	(.69)	.22	(.42)	-.57	(.35)	-.21	(.14)
F test	6.86 ***		6.13 ***		1.87 *		4.78 ***	
Adjusted R^2	.237		.214		.044		.167	
N	227		227		227		227	

(B) Mediating variables

	Model 1		Model 2		Model 3		Model 4		Model 5	
	%Industrial journal		%Clinical journal		%Academic journal		%Domestic journal		%Int'l coauthorship	
DV (5 year after graduation)	.32 ***	(.04)	.34 ***	(.05)	.43 ***	(.04)	.11 ***	(.03)	.08	(.09)
Univ rank	.15	(1.67)	-.78	(1.75)	2.06	(1.49)	.33	(.94)	-2.67 *	(1.12)
MD	-1.93	(4.47)	16.39 **	(5.15)	-5.14	(4.08)	-5.25 *	(2.57)	-2.51	(3.03)
Female	-3.43	(10.49)	-28.03 *	(10.93)	11.38	(9.27)	3.03	(5.98)	-10.35	(7.06)
#Years since first degree	-.38	(.30)	-.54 †	(.31)	.69 *	(.27)	.03	(.17)	-.02	(.21)
Inbred	-11.33 *	(5.10)	2.52	(5.32)	3.59	(4.53)	-.20	(2.91)	5.68 †	(3.37)
Time for research	1.94	(1.30)	1.29	(1.36)	-1.50	(1.16)	-.81	(.73)	-.63	(.86)
Time for teaching	1.94	(1.77)	-1.69	(1.85)	-.71	(1.57)	-.78	(1.00)	1.35	(1.19)
Time for administration	.59	(1.88)	-3.75 †	(1.96)	2.14	(1.67)	.79	(1.08)	-1.87	(1.27)
#Member	.37	(.42)	.72	(.44)	-.92 *	(.37)	-.52 *	(.24)	.41	(.28)
Budget/#member	.49	(.39)	.00	(.41)	-.21	(.35)	-.49 *	(.22)	-.07	(.26)
Foreign experience	1.59	(1.02)	1.72	(1.06)	-2.30 *	(.91)	-.96 †	(.57)	1.77 **	(.68)
F test	7.16 ***		11.44 ***		14.60 ***		4.95 ***		1.76 †	
Adjusted R^2	.253		.365		.428		.176		.039	
N	219		219		219		223		227	

[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 dropped. Returnees who return after 2006 are dropped, and those who left immediately or before graduation are dropped. The first independent variable is the same measurement as the dependent variable of each model but is computed for the five years after graduation.

(C) Mediating Model: dependent variable = %IF<2

	Model 1		Model 2		Model 3		Model 4	
%IF<2 (5 year after graduation)	.12 **	(.04)	.10 **	(.04)	.08 *	(.04)	.12 **	(.04)
Univ rank	-1.82	(1.13)	-2.39 *	(1.10)	-2.01 †	(1.06)	-1.74	(1.14)
MD	-6.53 *	(3.04)	-4.29	(3.00)	-3.91	(2.91)	-6.46 *	(3.04)
Female	4.58	(7.16)	1.94	(6.97)	4.31	(6.77)	4.93	(7.21)
#Years since first degree	.44 *	(.20)	.36 †	(.20)	.41 *	(.19)	.45 *	(.21)
Inbred	4.79	(3.43)	4.22	(3.33)	5.15	(3.24)	4.61	(3.46)
Time for research	.09	(.87)	.40	(.84)	.31	(.82)	.12	(.87)
Time for teaching	1.45	(1.21)	1.63	(1.17)	1.83	(1.14)	1.40	(1.21)
Time for administration	3.02 *	(1.28)	2.72 *	(1.24)	2.50 *	(1.21)	3.09 *	(1.29)
#Member	-.81 **	(.29)	-.63 *	(.28)	-.59 *	(.27)	-.83 **	(.29)
Budget/#member	-.75 **	(.27)	-.65 *	(.26)	-.53 *	(.26)	-.74 **	(.27)
Foreign experience	-1.63 *	(.69)	-1.13 †	(.68)	-1.22 †	(.65)	-1.69 *	(.70)
%Academic journal			.16 ***	(.04)				
%Domestic journal					.40 ***	(.08)		
%Int'l coauthorship							.03	(.07)
F test	6.86 ***		7.91 ***		9.18 ***		6.33 ***	
Adjusted R^2	.237		.284		.320		.235	
N	227		227		227		227	

(D) Difference Model

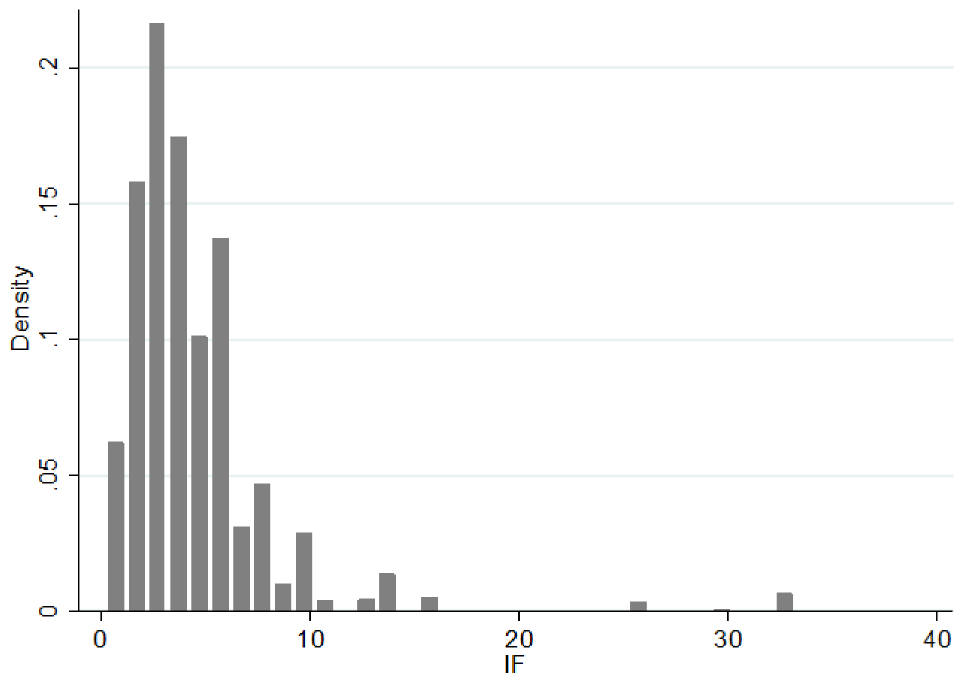
	Model 1 Δ%IF<2		Model 2 Δ%IF<2		Model 3 Δ%0-cites		Model 4 Δ%0-cites	
ΔUniv rank	2.83 †	(1.63)	2.12	(1.44)	2.38	(1.72)	1.40	(1.72)
Δyear (#years since degree)	-.01	(.14)	.26 †	(.14)	-1.58 ***	(.15)	-1.54 ***	(.16)
Foreign experience (1 year or more)	-7.73 †	(4.40)	-10.03 *	(3.91)	-8.11 †	(4.64)	-7.39	(4.68)
Δ%Academic journal			6.47	(9.30)			-5.84	(11.14)
Δ%Domestic journal			38.04 ***	(5.84)			13.77 †	(7.00)
Δ%Int'l coauthorship			-11.36 †	(6.50)			3.06	(7.79)
F test	6.37 ***		11.00 ***		161.87 ***		85.20 ***	
Adjusted R^2	.066		.213		.678		.696	
N	229		221		229		221	

Table 5 Prediction on Publication Count [a]

	Model 1 #Pub/#member		Model 2 #IF<2/#member		Model 3 #IF>2/#member		Model 4 #0-cited/#member		Model 5 #cited/#member	
DV (5 year after graduation)	.13 *	(.05)	.15 ***	(.04)	.09 †	(.06)	.00	(.01)	.20 **	(.07)
Univ rank	-.25	(.23)	-.20 *	(.09)	-.04	(.19)	-.02	(.03)	-.21	(.18)
MD	-.63	(.61)	-.33	(.24)	-.25	(.51)	-.07	(.08)	-.75	(.49)
Female	-1.42	(1.43)	-.19	(.57)	-1.26	(1.19)	-.08	(.19)	-1.35	(1.15)
#Years since first degree	.04	(.04)	.01	(.02)	.03	(.03)	.00	(.01)	.07 *	(.04)
Inbred	1.07	(.68)	.38	(.27)	.66	(.56)	.11	(.09)	.41	(.55)
Time for research	-.26	(.17)	-.04	(.07)	-.23	(.14)	-.03	(.02)	-.17	(.14)
Time for teaching	.06	(.24)	.04	(.10)	-.01	(.20)	.03	(.03)	.06	(.20)
Time for administration	-.45 †	(.26)	-.02	(.10)	-.44 *	(.21)	-.03	(.04)	-.31	(.21)
#Member	-.18 **	(.06)	-.08 ***	(.02)	-.10 *	(.05)	-.02 **	(.01)	-.14 **	(.05)
Budget/#member	.19 ***	(.05)	.01	(.02)	.19 ***	(.04)	.00	(.01)	.18 ***	(.04)
Foreign experience	-.21	(.14)	-.11 *	(.06)	-.11	(.12)	-.04 *	(.02)	-.18	(.11)
F test	4.78 ***		5.48 ***		3.67 ***		2.32 **		5.14 ***	
Adjusted R^2	.167		.192		.124		.066		.180	
N	227		227		227		227		227	

[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 (Fixed-effects model). Respondents who published five or fewer papers in 2006-2010 are dropped. Returnees who return after 2006 are dropped, and those who left immediately or before graduation are dropped.

Appendix 1 Distribution of Impact Factor in Biochemistry & Molecular Biology in 2010 [a]



[a] The distribution is weighted by the number of articles published from each journal.

Appendix 2 Prediction of Publication Impact at Individual Level for those who have published at least one high-IF paper

	Model 1 %IF<2		Model 2 %IF>8		Model 3 #Pub/#member	
Univ rank	-.32	(.84)	1.07	(.66)	.02	(.27)
MD	-3.85 †	(2.11)	4.12 *	(1.67)	.58	(.68)
Female	1.77	(5.94)	6.82	(4.69)	-2.13	(1.92)
#Years since first degree	.48 ***	(.14)	-.50 ***	(.11)	.11 *	(.05)
Inbred	4.13	(3.21)	-3.32	(2.53)	2.08 *	(1.03)
Foreign experience	-1.13 *	(.56)	.41	(.45)	-.46 *	(.18)
Time for research	.28	(.62)	1.44 **	(.49)	-.58 **	(.20)
Time for teaching	1.14	(.89)	.57	(.70)	.42	(.29)
Time for administration	1.67 †	(.86)	.71	(.68)	-.77 **	(.28)
#Member	-.45 *	(.20)	.35 *	(.15)	-.29 ***	(.06)
Budget/#member	-.96 ***	(.27)	.39 †	(.21)	.15 †	(.09)
F test	4.53 ***		5.46 ***		5.44 ***	
Adjusted R^2	.137		.167		.167	
N	245		245		245	