Research Policy 44 (2015) 936–950

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Impact-oriented science policies and scientific publication practices: The case of life sciences in Japan

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ARTICLE INFO

Article history:
Received 28 January 2014
Received in revised form 12 January 2015
Accepted 22 January 2015
Available online 13 March 2015

Keywords:
Scientific production
Publication
Impact factor
Science policy
Evaluation

ABSTRACT

The modern science system relies on intense evaluation of scientific publication, in which scientific impact is highly emphasized, but its contribution to the progress of science has been controversial. Focusing on two aspects of the science system, resource allocation and academic career design, this study explores whether these policies, presumably aiming at high-impact research, actually achieve the goal. Drawing on in-depth interviews and econometric analyses of Japanese biology professors, this study first shows that merit-based resource allocation can result in biased resource allocation, and that excessive resource concentration can facilitate low-impact publications. Second, results show that a lack of mobility, in particular inbreeding, increases low-impact publications, while international mobility decreases it. The latter effect is found to be mediated by fewer publications in low-impact journals, and thus, internationally mobile academics seem to decide the publication destination more strategically.

1. Introduction

During the last few decades, economic policies have emphasized the role of science in innovation and economic growth (Etzkowitz and Leydesdorff, 2000; Stephan, 2012). While this has substantially increased the investment in science, the academic sector has been subject to stricter pressure for accountability (Hagstrom, 1974). The performance of scientific research has been scrutinized increasingly on the basis of scientific publications, the primary and arguably measurable output of science (Geuna and Martin, 2003; Hicks, 2012). Academics and universities are evaluated and ranked with various metrics of publication performance (e.g., Hirsch, 2005; Narin and Hamilton, 1996), with which research budgets are distributed, and academic positions are allotted (Geuna and Martin, 2003; Hicks, 2012). Consequently, publication has been reduced to a means to survive the fierce competition, resulting in the academic culture often referred to as "publish or perish" (Dasgupta and David, 1994; Laband and Tollison, 2003).

Although the emphasis on publication-based evaluation may be justified for objectivity and transparency, whether it contributes to the advancement of science is not entirely clear. Indeed, the past decades have seen a significant boost in the volume of publications (Reich, 2013), but for example, Bohannon (2013) points out that this is partly due to numerous new journals with questionable scientific legitimacy. Anecdotes suggest that poorly designed policies can facilitate rent-seeking behavior, such as fragmented publications and redundant publications, and only improve superficial performance (e.g., Broad, 1981; Martin, 2013). The Australian funding system is an infamous example; the system was reformed so that research block grants should be awarded based partly on publication count, and this resulted in a greater number of publications but of lower quality in terms of journal impact (Butler, 2003).

In an attempt to facilitate valuable publications rather than only to inflate publication count, policymakers have been emphasizing the *impact* of publications (Geuna and Martin, 2003; Hicks, 2012). This is often implemented by evaluating some citation indices on the premise that highly cited papers offer an important foundation for subsequent research (Cole and Cole, 1972). Nevertheless, this approach is not immune to rent-seeking behavior. For example, some journal editors were found to coerce authors under peer review to cite the editors' papers (Wilhite and Fong, 2012), and some universities offer part-time employment to highly cited academics with the condition that the university name be added in their publications (Bhattacharjee, 2011). More commonly, academics are making considerable efforts to publish in so-called prestigious or high-impact journals that are likely to invite many

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http://dx.doi.org/10.1016/j.respol.2015.01.012
0048-7333/

citations, which may or may not be accompanied by contents of high impact (Frank, 1994; Gordon, 1984). Criticizing this situation, Holub et al. (1991) stated "*where* a scientist publishes has become much more important than *what* he is publishing." With all the painful efforts of academics, however, numerous papers remain uncited while only a tiny portion of papers are highly cited (Cole and Cole, 1972; Redner, 1998; Seglen, 1992).

Overall, the current science policies with extreme emphasis on publication could cause academics' strategic behavior, resulting in publications with limited scientific value and social benefit. This study aims to investigate how academics' publication practices are affected by science policies, particularly focusing on career system and resource allocation, two pivotal components of the science system that are increasingly subject to publication-based evaluation. Though academics' rent-seeking behavior, particularly misconduct, has attracted increasing scholarly attention (Martin, 2013), prior literature has been mostly descriptive or conceptual. A few lines of literature have studied the effect of science policies on publication performance (Baruffaldi and Landoni, 2012; Crespi and Geuna, 2008; Cruz-Castro and Sanz-Menendez, 2010; Jacob and Lefgren, 2011) but paid limited attention to academics' strategic reactions to the policies. To go beyond the prior literature, we draw on two approaches: (1) in-depth interviews to qualitatively illustrate academics' publication practices, and (2) econometric analyses based on a questionnaire survey and bibliometric data. For the latter, we analyze the publication portfolio, i.e., a combination of different types of publications, particularly in terms of publication impact, to infer academics' strategies. This study uses a sample of Japanese biology professors, which offers an interesting case in that the country is highly ranked in life sciences (Adams et al., 2010) and yet commonly produces low-impact publications (Appendix 1).

This paper is structured as follows: Chapter 2 reviews prior literature on scientific publication and the focal policies. Chapter 3 describes our data. Chapter 4 illustrates the policy context of our sample and presents qualitative results mainly from our interviews, and Chapter 5 presents the results of econometric analyses. Finally, Chapter 6 summarizes the results and discusses the implications.

2. Literature review

2.1. Incentive for publication and strategic publication

The advancement of science essentially relies on the publication of scientific papers. Academics are obliged to publish their findings to share among the scientific community for verification and reuse in subsequent research (David, 2004). Publication has been driven traditionally by an internal reward system based on peer reputation (Merton, 1973). As academic science has been incorporated as a core part of the innovation system, however, academics and universities have been subject to stricter external control, and their performance has been evaluated based on publication records (Geuna and Martin, 2003; Hicks, 2012). Publication records are easily accessible from public and commercial databases (e.g., Web of Science, Scopus, PubMed) and the metrics of publication performance are computed. With these metrics, academic institutions and countries are evaluated and ranked (e.g., Research Assessment Exercise in the UK and similar systems in other countries,[1] Academic Ranking of World Universities, etc.), further reinforcing the political pressure for publication.

A challenge in publication-based evaluation is that the value of each publication can differ significantly, and thus, simply counting publications does not usually suffice. Among multifaceted value of publications, the concept of *impact* — i.e., the extent to which a publication or a set of publications offers the basis for subsequent research — has been popularly used (Geuna and Martin, 2003; Hicks, 2012). On the grounds that influential discoveries are likely to be frequently cited (Cole and Cole, 1972), evaluation systems often draw on some forms of citation indices (e.g., H-index). Although academics are aware of limitations of this approach, impact-oriented evaluation is prevalent (Bornmann and Daniel, 2008; Macroberts and Macroberts, 1996; Van Raan, 2005).

Under the publish-or-perish academic culture, it is essential for individual academics to improve publication metrics to survive career filters throughout all career stages (Dasgupta and David, 1994; Laband and Tollison, 2003). Even after obtaining a tenured position, they have to keep fundraising to cover research expenses, for which excellent publication records are needed, and a lack of funds could mean an exit from a research career. This extreme pressure for publication seems to affect academics' practices in research in many ways. It could broadly induce questionable research practices and compromise scientific integrity (Anderson et al., 2007; Fanelli, 2010; Martin, 2013). Particularly as to publication, academics resort to various types of rent-seeking behavior such as fragmented publication, redundant publication, plagiarism, and other types of misconduct (Martin, 2013). A typical strategic behavior is also observed in the choice of journals for publications. Responding to the emphasis on impact, academics attempt to publish in prestigious journals that are likely to attract citations. This has led to the popular use of *journal impact*, on the basis of which academic journals are ranked (Garfield, 1972). Journal impact is known as one of the most important decision criteria when academics choose a journal for publication (Frank, 1994; Gordon, 1984). These observations imply that the policy emphasis on publication-based evaluation has changed academics' publication practices, although empirical evidence is lacking with few exceptions (Butler, 2003).

2.2. Publication for career development

As the phrase "publish or perish" implies, the academic career system is the primary source of pressure for publications. Junior academics such as PhDs and postdocs have to present appealing vita to win entry positions, and those who did have to further develop publication records within several years to attain tenured positions. The academic career system used to be (and still is, depending on countries) rather closed and less dynamic. Particularly during the early days of the university system, faculty members tended to be developed internally with limited mobility (Horta et al., 2011). In the modern science, however, immobility and inbreeding are generally perceived as an impediment to performance, and mobility is regarded as a career requirement in many countries (EC, 2010; OECD, 2008; Stephan, 2012). The rationale behind pro-mobility policies is that mobile academics can recombine their knowledge with that of other academics in host affiliations and find a research environment that best matches their skills (Agrawal et al., 2011; Hargadon and Sutton, 1997). Recent policies have particularly emphasized international mobility as a means to facilitate international collaboration and global competitiveness (Stephan, 2012). In fact, Franzoni et al. (2012) show that 40–80% of academics in most developed countries, except for the US, have international experience for one year or longer. Pro-mobility policies can also be popular for employers (e.g., universities) in that long-term employment commitment can be avoided and that faculty teams can be flexibly reorganized under varying social needs and severe budgetary constraints. Consequently, academic contracts have become shorter, and tenure contracts have been replaced by temporary

[1] The UK has been moving away from Research Assessment Exercise (RAE) to Research Excellence Framework (REF). Similar funding systems are observed in Australia and some European countries (Hicks, 2012).

ones or weakened so that underperforming professors can be dismissed (Clawson, 2009).

With this transitioning of the academic career system, evaluation systems have also been changing. Unlike the inbreeding context, in which candidates can be evaluated on a daily basis through the master-apprentice relationship, evaluation needs to be based on output rather than on process, and the demand for accountability requires objective evidence (Geuna and Martin, 2003; Hicks, 2012). This has naturally led to publication-based evaluation, and shorter-term contracts pressure academics to develop publication records constantly. This unprecedented pressure for publication is likely to affect academics' publication practices, as implied by the recent increase in unethical practices (Grieneisen and Zhang, 2012). Nevertheless, the literature on career design has paid limited attention to such aspects while primarily investigating aggregate publication performance (Baruffaldi and Landoni, 2012; Cruz-Castro and Sanz-Menendez, 2010; Geuna, 2014).

2.3. Publication for resource allocation

While securing employment is a necessary condition to remain academic researchers, it is usually insufficient. Scientific research, especially in the natural sciences, is resource-intensive and heavily dependent on costly input such as experimental devices (e.g., DNA sequencers, NMR, etc.), model animals (e.g., mice), and the labor of students and postdocs (Stephan, 2012). By way of example, Stephan (2012) estimates that hiring eight researchers in a middle-sized laboratory costs about $350,000 per year. Thus, fundraising and resource procurement is a major concern for principal investigators (PIs) of laboratories.

Resource allocation used to be less competitive and relatively uniform among academics when scientific research was much less costly (Hicks, 2012).[2] As research cost increased and the enterprise of science expanded, however, governments and other sponsors have become selective. With the demand for accountability, resource allocation has become based on objective evaluation, and the funding system has shifted toward competitive one both at the institutional and individual levels (Geuna and Martin, 2003; Hicks, 2012).

Competitive resource allocation tends to bias resource distribution in a cumulative manner. That is, well-funded academics are likely to produce more than poorly-funded academics, and this allows the former to attract even more resources in the next round of allocation, which is known as the Matthew effect (Merton, 1968). This tendency is even stronger when funding agencies are risk-averse since funding those who have the evidence of scientific performance appears secure. Furthermore, policymakers often strategically concentrate resources on prominent academics to facilitate prize-winning research, to win national competition, and so forth (Fortin and Currie, 2013). This can result in excessively biased resource allocation, where a small number of academics are oversupplied and many are poorly supported. For example, Hand (2008) finds that 200 PIs received six or more grants and one PI received as many as 32 grants from the US National Institutes of Health (NIH) in 2007.

Amid the intense funding competition, academics' funding practices have been changing. They are making various efforts to mitigate the risk of funding deficit. For example, academics are known to adjust, at least superficially, their research fields to where funding is abundant (Gillum et al., 2011). In addition, they submit many proposals, possibly more than necessary, to increase the likelihood of acceptance. A case study of US National Science Foundation suggests that excessive proposals have actually lowered the overall acceptance rate and forced academics to write even more proposals (Mervis, 2014). As a result, academics have to spend considerable time on funding at the cost of research time; PIs nationally funded in the US are found to spend 42% of their research time on funding-related tasks (Rockwell, 2009). Concerning the effect of resource allocation on publication, previous literature has two limitations. First, most literature has attempted to assess ultimate performance with limited attention to academics' publication practices (Baruffaldi and Landoni, 2012; Crespi and Geuna, 2008; Cruz-Castro and Sanz-Menendez, 2010; Jacob and Lefgren, 2011). Second, most empirical studies have focused on publications at macro levels (e.g., universities, countries) rather than at the individual level possibly due to limited data availability, hindering our understanding about individual academics' behavior.

3. Data

For empirical analyses, this study draws on a sample of Japanese biology professors for the following reasons. First, the Japanese science system used to be fairly free from extrinsic incentives for publication, but policymakers have recently reformed various aspects of the science system, including funding, employment, and promotion with greater emphasis on impact (Kneller, 2007). We expect that this transitional state should help highlight policy effects. Second, while Japan is highly ranked in life sciences (Adams et al., 2010), it also produces a high rate of low-impact publications compared to other developed countries (Appendix 1). This allows us to examine the determinants of both low and high-impact publications. Third, the field of biology is chosen because the standard of journal impact, which we exploit for econometrics, has attained a reasonable consensus (Mcallister et al., 1980; Saha et al., 2003).

We obtained our data from four sources. First, we conducted interviews of 30 PIs in biology. Each interview took from 1 to 2 h. We inquired into their publication strategies, the influence of recent policy reforms, evaluation criteria in their departments, and so forth. Second, we conducted a questionnaire survey in 2010.[3] We selected our survey sample with the following criteria. We first chose professors who are PIs of laboratories, and thus, are the primary decision-makers in publication. Then, we selected PIs who received national grants in the field of biology at least once in 2007–2009 to make sure that they were active researchers. We prepared a list of 1378 PIs from a database of national research grants.[4] After re-examining their research fields and affiliations with public information, we identified 900 PIs in 56 universities as a final sample.[5] We designed our survey instrument based on the interviews. We mailed the survey by post and collected 396 responses (response rate = 44%).[6] Dropping some respondents with incomplete answers, we obtained 377 PIs as our final sample. The

[2] Shibayama (2011) shows that funding distribution used to be less skewed in Japan. We suppose that increasing use of performance-based resource allocation has skewed resource allocation also in other countries though precise information about funding distribution is often inaccessible.

[3] The survey covered several topics such as lab management, collaboration, career building, and resources for research. This study draws on a relevant part.

[4] Source: the database of Grants-in-Aid for Scientific Research (http://kaken.nii.ac.jp/).

[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, of which about 50 are engaged in some life science research, 95 regional universities, and 597 private universities (*School Basic Survey by Ministry of Education, Culture, Sports, Science and Technology*: http://www.e-stat.go.jp/). Our sample covers most of the relevant national universities and several private and 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 ($p > .1$).

respondents have 26 years of academic career on average. Only 11 respondents are female. Third, we obtained career information of the respondents from a national CV database.[7] Fourth, using the Web of Science (WoS), we collected the data of approximately 40,000 articles that our respondents authored up to 2010.

Chapter 4 shows qualitative results from the interviews supplemented by the questionnaire data,[8] and then, Chapter 5 presents econometric results based on the questionnaire and bibliometric data.

4. Context of Japanese science system and interview results

Drawing on our survey and policy documents, this chapter qualitatively illustrates the Japanese policy context and how the context could affect publication practices.

When informed about the higher rate of low-IF publication in Japan compared to that in other developed countries (Appendix 1), most of our interviewees suggested that the Japanese science system traditionally rewards for the volume of publications. For example, promotion criteria often include the minimum publication count; funding evaluation appreciates publication count, so applicants list as long a publication record as possible. PhD students in some universities have to publish a certain number of papers to earn a degree. However, as the standard of science gradually improved, the quality of publications has been appreciated. Policymakers have reformed various aspects of the science system with greater emphasis on impact since the 1990s (Kneller, 2007 CNUFM, 2009). A major reform began with the enactment of the Science and Technology Basic Law in 1995 with the aim of tackling the economic downturn by reinforcing scientific and technological capital. This has substantially increased the government funding on academic research. In 2004, national universities were incorporated, and each university was given greater managerial autonomy. Simultaneously, universities have been placed under stricter evaluation pressure as the government emphasized competitive funding based on performance.

4.1. Concentrated resource allocation

Japanese academics obtain research budgets mainly from three sources: non-competitive block grants for universities, competitive grants for universities, and competitive grants for individual academics.[9] As is the global trend, the reform of the Japanese science system has been emphasizing merit-based resource allocation. In 2002, the government claimed that it would selectively finance universities to establish 30 globally competitive universities. Since 2004, the block grants, which used to be stably awarded according to certain formula, have been reduced by one percent every year, while various competitive funding systems have been introduced. Simultaneously, competitive grants for individual academics have been greatly increased. In particular, the primary competitive funding source for Japanese academics, Grants-in-Aid (GiA) for Scientific Research, increased four times since 1990.

These reforms have skewed the distribution of research budgets. Shibayama (2011), investigating the distribution of GiA as of 2005, found that the top 10% of PIs received approximately 60% of the total research budgets and that about 15% of PIs received multiple grants, with one PI involved in more than 20 granted projects.[10] Such a biased allocation has been occasionally criticized by Japanese academics for its potentially inefficient use and lack of transparency in the evaluation process, while some academics appreciate strategic concentration of resources. Our survey respondents unanimously voiced a concern that competitive resource allocation based on short-term evaluation could compromise basic research whose value can be realized only in the long term. Before the reform, the block grants used to play a fundamental role to sustain such research (Kneller, 2007), but the shift toward competitive funding has deprived academics, particularly in low-ranked universities, of this base budget, forcing some to abandon a research career. Criticism has been expressed not only by poorly funded academics. Five of our interviewees, who were well funded, also admitted potential downsides of competitive funding. Namely, PIs who receive excessive budgets are likely to use it up rather than to return any unspent amounts to funding agencies. However, PIs can have only a limited number of research ideas, so they may need to resort to their second or third best ideas in order to spend all the budgets, knowing that these might yield only mediocre results. Further, three interviewees contended that skewed funding distribution has allowed a “mass production strategy”. That is, some PIs recklessly carry out numerous projects without carefully designing them, hoping that a few of them turn out innovative by chance at the cost of many mediocre results. One interviewee stated:

> 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.

Apparently, such a strategy is collectively inefficient but can be individually rational if the critical mass for accidental discovery is not terribly high. What is worse, this strategy is tempting once PIs are awarded a large budget. A large budget tends to be invested in additional employment and expensive facilities, but because they entail long-term cost, downsizing the laboratory is not easy. 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 wanted to maintain the same size of budget. Having a lot of money is not bad, but writing funding proposals and reports is time-consuming. Looking back on my career, I wish I had used my time more on research itself than on fundraising.

In addition to funding allocation, the reform has skewed the distribution of human resources. The primary workforce in Japanese laboratories is PhD students rather than postdocs. During the 1990s, the overall quota of postgraduate courses was doubled in an attempt to reinforce graduate education (NISTEP, 2009), but after a decade, this has created many PhDs and postdocs without stable employment (Cyranoski et al., 2011). This bleak prospect of an academic career, along with a shrinking young population, has significantly decreased PhD applicants (NISTEP, 2009). Nevertheless, the student quota has been kept, resulting in an unequal distribution of PhD students, with low-ranked universities having fewer students and high-ranked universities having more students. While PIs in low-ranked universities are apparently in trouble running their laboratories, the situation in high-ranked universities is mixed with some laboratories aggressively recruiting many stu-

[7] Source: Directory Database Research and Development Activities (http://researchmap.jp/).

[8] In the questionnaire survey, we asked for free comments about any concern or recommendation about science policies, and approximately one-third of the respondents gave some comments. We use them to supplement interview comments. The summary of the qualitative data is shown in Table S1 in Supplementary data.

[9] Though funding from industry is common in life sciences, its proportion is still modest. The governmental report indicated that funding from industry accounted for approximately five percent (CNUFM, 2009).

[10] The government attempted to mitigate these issues after criticism from science communities by setting a ceiling on the number of simultaneous grants (Shibayama, 2011).

dents while others keeping the same size or shrinking. Three of our respondents in the latter group criticized the former, pointing out that some laboratories in top universities accepted more students than they could take care of. As prior literature suggested, the overconcentration of students should lower the quality of student training and research performance (Salonius, 2008). One PI of a medium-sized laboratory stated:

> 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 compromises collective productivity.

In summary, the policy reform seems to have resulted in excessive concentration of budget and human resources, and well-resourced academics might have shifted their efforts toward mediocre research projects rather than to concentrate on selected promising ones.

4.2. Mobile career design

The academic career system in Japan is characterized by a chair system modeled on the German system, in which a PI (full professor) organizes a laboratory and supervises junior professors and other staff as a team (Kneller, 2007). This lab structure has created hierarchical mentoring relationship between a PI and subordinate members. Regarding employment and promotion of junior professors, the PI's voice is highly respected, and candidates for promotion are often selected within the chair; i.e., inbreeding is common (Yamanoi, 2007). Full professor positions are usually made open when a chair retires, and it is often the case that previous associate professor in the same chair is promoted. Overall, the chair system tends to result in life-time employment and internal promotion based more on seniority (Horta et al., 2011). However, policymakers have recognized this rigid career structure as an impediment to scientific performance and began to revise the system modeled more on the American system (Lawson and Shibayama, 2015). In 1997, national universities were allowed to employ faculty members on temporary contracts. Since then, permanent contracts have been gradually replaced by temporary contracts with the intention to increase mobility. In 2001, national universities were advised to employ faculty members through open competition. In 2006, a tenure-track system was introduced though it is still in a preliminary stage.

Although inbreeding could eliminate the pressure from external competition and offer stable research conditions (Horta et al., 2011), most of our survey respondents emphasized negative aspects of inbreeding. 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 limited incentive to risk abandoning the established topics (Morichika and Shibayama, 2015). A professor with a highly mobile career mentioned from his observation of inbred colleagues:

> In my impression, inbred academics tend to emphasize the volume 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 continuing the same research agenda even though such an approach might lack originality.

In this regard, academic mobility can function as a means to promote publication impact. Most of our survey respondents recommended diverse experience through mobility. In particular, they emphasized the importance of international experience. In fact, Japanese science policies have long encouraged international mobility (MEXT, 2009). Of our respondents, 77% had one year or longer of research experience abroad (mostly in the US). A characteristic of the international mobility policy in Japan is that foreign stay usually occurs only temporarily; i.e., academics are expected to return home after a few years. Franzoni et al. (2012) find that 92% of internationally mobile Japanese academics are employed in Japan, and that only 5% of academics working in Japan are foreign-born. Thus, the Japanese scientific community is rather homogeneous in terms of nationality and somewhat detached from the rest of the world. This might differentiate research practices between internationally mobile academics and immobile academics. As described above, the Japanese science system traditionally rewards the volume of publication, but this seems to be different from other developed countries (Appendix 1). In particular, Hamermesh and Pfann (2012), with a case study of American economics, suggest that publishing many mediocre papers compromises academics' reputation in the US. This contrast in the norm of publications was highlighted by our two interviewees who used to have professorships in the US. They were critical about volume-oriented publication practices and emphasized the quality of publication.

> 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 four 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 two are minimally acceptable. Publishing in journals with an IF less than one is meaningless since nobody would read such journals.

These comments imply that internationally mobile academics might have acquired higher quality standards in competitive environment. Simultaneously, they seem to have been adapted to impact-oriented publication practices and become more concerned about where their papers are published.

In summary, immobility seems to compromise publication impact while mobility, especially international mobility, seems to facilitate it. In the Japanese policy context, international mobility occurs mostly in the US, and returnees from the US seem to have acquired higher-quality standards as well as publication practices favoring higher impact.

5. Regression analyses of publication impact

5.1. Analytical approach and measures

5.1.1. Portfolio of publication impact

This chapter explores policy effects on publication practices using the questionnaire and bibliometric data. Unlike most prior literature examining aggregate performance, we draw on the portfolio of publication impact. The impact of publications is measured by the citation count each publication receives by convention. In addition, we draw on Impact Factor (IF) of journals where each paper is published (Garfield, 1972).[11] We argue that policy interventions can affect the publication portfolio through academics' decisions in two points: (1) the type of research they conduct and (2) the way research results are published. We use citation count for the former and IFs (i.e., choice of journals) for the latter. Though IF is a controversial metric (Weingart, 2005), it has attained a high consensus particularly among life scientists (Mcallister et al., 1980; Saha et al., 2003). Our interviewees also suggested that their perceived journal quality reasonably agrees with IFs, and that IFs are commonly used in formal evaluations. Thus, we suppose that academics' choice of journals in terms of IFs well reflects their strategies. Certainly, journal choice can be beyond academics' control (i.e., submitted papers can be rejected), but Calcagno et al. (2012) find 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.

To measure the portfolio of impact, we categorize high, low, and middle-impact publications, respectively defined as top-10%-cited, bottom-10%-cited, and the rest of publications. To identify the top-10% and bottom-10% citation counts, we use citation data of all papers published in the same year in the field of Biochemistry and Molecular Biology (BMB).[12] Similarly, we categorize high, low, and middle-impact journals identified by the top-10%, bottom-10%, and in-between IFs. The thresholds of the top-10% and bottom-10% of IFs are approximately 1.6 and 7.8 in BMB according to JCR2010,[13] which coincide well with the perception of our interviewees, who mentioned 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." Finally, we computed the percentage of bottom-10% and top-10%-cited papers among all papers published by each respondent in 2006–2010 (*%low cites* and *%high cites*). Similarly, we computed the percentage of low-IF and high-IF papers (*%low IF* and *%high IF*).

5.1.2. Portfolio of publication types

Since academics may publish for non-scientific objectives, useful publications can end up uncited (Macroberts and Macroberts, 1996; Redner, 1998). For example, publications intended for practical application may not be cited by academic peers although read by practitioners, and therefore, considered of low impact. To incorporate such possibilities, we control for the portfolios of several publication types. First, we categorize industry-oriented and clinical-oriented journals, following Tijssen (2010), who identifies industrial journals and clinical journals.[14] We computed the percentages of publications of respective journal types for each respondent (*%industrial journal* and *%clinical journal*). Second, publications in domestic journals tend to have smaller audience and be less cited (Van Leeuwen et al., 2001). Perhaps, academics publishing in domestic journals may report domestically relevant discoveries or intend for local communication.[15] Thus, we identified publisher of all journals and computed the percentage of domestic (i.e., Japanese) journals (*%domestic journal*).[16] Third, PIs may have their students publish papers for educational purposes, in which scientific impact is secondary. We computed the percentage of papers first-authored by PhD students because first authors tend to be the primary contributor in biology (*%student first author*).[17] Finally, because internationally coauthored papers tend to be more cited (Narin et al., 1991), we computed the percentage of internationally coauthored papers for each respondent based on the authors' address (*%international coauthorship*).

5.1.3. Independent variables

As for resource allocation, we surveyed the total research budget in the year of 2010 with a 7-point scale: 1 = less than 5 million JPY (roughly $1 = 100 JPY), 2 = 5–10, 3 = 10–25, 4 = 25–50, 5 = 50–75, 6 = 75–100, and 7 = greater than 100 (*budget*). We also asked the number of PhD holders (i.e., senior staff and postdocs) and PhD students, respectively, in respondent's laboratory. Then, we computed the summation of these numbers as a lab size (*#member*). Further, we calculated budget per member (*budget/#member*)[18] and the number of students per staff (*#student/#staff*) to measure the resource intensity. As for academics' career, we prepared two variables. First, we measured the extent of inbreeding by the number of years for which academics stay after graduation in the same university that granted the degree (*inbred*).[19] Second, we surveyed 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*).

5.1.4. Control variables

We control for university rank based on the amount of competitive research grants with a four-point scale: 4 = 1st or 2nd, 3 = 3rd–7th, 2 = 8th–20th, and 1 = 21st or below (*univ rank*).[20] We

[11] 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/). The IF data is obtained from Journal Citation Report (JCR).

[12] In each publication year, we identified the citation count that top-10% and bottom-10%-cited papers received in the WoS Subject Category of Biochemistry and Molecular Biology (BMB). Due to our sampling criteria, our respondents are mostly basic biologists, and the largest proportion (32%) of their papers are published in BMB. We also prepared a field-adjusted citation measures and obtained similar results. We obtained citation data as of July 2014, which is four years after the most recent papers in our analysis are published (in 2010). The top and bottom-10% citation counts are 2 and 32 for BMB publications in 2010.

[13] The distribution of IFs in BMB is given in Fig. S2 in the Supplementary data.

[14] The journal categories are determined based on author affiliations. Journals whose authors tend to be affiliated to firms are categorized as industrial, and journals whose authors tend to be affiliated to hospitals are categorized as clinical. One journal can be both industrial and clinical. This categorization is a refinement of the CHI classification (Narin and Hamilton, 1996).

[15] Another rationale to publish in domestic journals may be that writing in a domestic language is less costly. From our CV analyses, we found that publications in domestic journals in the field of biology are limited in comparison to the social sciences, where Japanese scientists often write in Japanese.

[16] Because of limited coverage of the WoS, our measurement is likely to underestimate the percentage of domestic journals (Van Leeuwen et al., 2001).

[17] 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 the WoS, we matched the publication data with the dissertation data and identified PhD students in the author list of each paper.

[18] For this, we cardinalize the measure of *budget*: 1 = 2.5 million JPY, 2 = 7.5, 3 = 17.5, 4 = 37.5, 5 = 67.5, 6 = 87.5, and 7 = 100, and then, divide it by the number of members.

[19] Since some respondents graduated as late as 1998, we truncated this measure at 10 years as the maximum.

[20] This categorization is based on the fact that top seven universities enjoy prestigious status as pre-imperial universities, and that Universities of Tokyo and Kyoto are exceptional among others. For this measurement, we drew on the database of Grants-in-Aid for Scientific Research. The whole budget in 2013 was

Table 1
Descriptive statistics and correlation matrix.[a]

	Variable	Mean	SD	Min	Max	Median	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	%Low cites	15.12	14.50	.00	100.00	11.43																	
2	%Low IF	15.93	18.58	.00	100.00	9.38	***.493***																
3	%High cites	8.19	11.08	.00	70.00	12.50	***−.362***	**−.357**															
4	%High IF	10.24	12.80	.00	77.78	6.25	***−.376***	**−.380**	**.653**														
5	%Industrial journal	56.60	29.55	.00	100.00	62.50	***−.185***	**−.254**	**.130**	**.186**													
6	%Clinical journal	39.92	31.79	.00	100.00	40.00	***−.251***	**−.493**	**.253**	**.247**	**.188**												
7	%Domestic journal	17.30	16.91	.00	80.00	11.76	**.286**	**.600**	**−.268**	**−.339**	**−.192**	**−.433**											
8	%International coauthorship	23.11	18.16	.00	100.00	20.00	−.097	−.023	**.214**	**.200**	**−.143**	.037	**−.137**										
9	%Student first author	15.71	14.38	.00	66.67	12.50	−.031	.033	**−.136**	−.083	.040	−.001	**.134**	**−.224**									
10	Univ rank	2.23	1.08	1.00	4.00	2.00	**−.249**	**−.172**	**.217**	**.214**	.032	.005	−.077	−.046	**.246**								
11	Female	.03	.17	.00	1.00	.00	.001	−.041	−.046	.005	−.053	−.067	−.031	.002	−.041	−.036							
12	#Years since first degree	25.99	5.86	12.00	45.00	26.00	.088	.091	**−.181**	**−.219**	−.054	−.005	.042	.022	**.107**	.052	−.046						
13	Inbred	2.61	3.94	.00	10.00	.00	.004	.048	−.022	−.016	−.012	.065	.022	−.037	.060	**.184**	−.051	.047					
14	Foreign experience	3.61	1.54	1.00	6.00	4.00	−.097	**−.187**	.007	.076	.076	**.173**	**−.130**	**.211**	−.046	−.024	.074	**.231**	**−.168**				
15	#Member	7.04	4.25	1.00	38.00	6.00	**−.207**	**−.181**	**.333**	**.270**	**.111**	**.215**	**−.207**	.048	.067	**.366**	−.072	.043	.030	.041			
16	Budget	3.19	1.51	1.00	7.00	3.00	**−.331**	**−.315**	**.459**	**.405**	**.219**	**.283**	**−.304**	.025	−.041	**.311**	−.074	.005	.075	.065	**.574**		
17	Budget/#member (JPY(in million))	4.01	3.82	.28	37.50	3.41	**−.134**	**−.171**	**.193**	**.181**	**.147**	**.107**	**−.188**	−.025	**−.120**	.028	−.047	−.055	.005	.029	−.037	**.603**	
18	#Student/#staff	.77	.74	.00	4.33	.50	−.048	.036	.003	−.053	−.054	−.021	.063	.025	.097	.090	.020	.054	−.014	.048	.253	−.074	**−.230**

[a] $N = 377$. Bold italic is significant ($p < .05$).

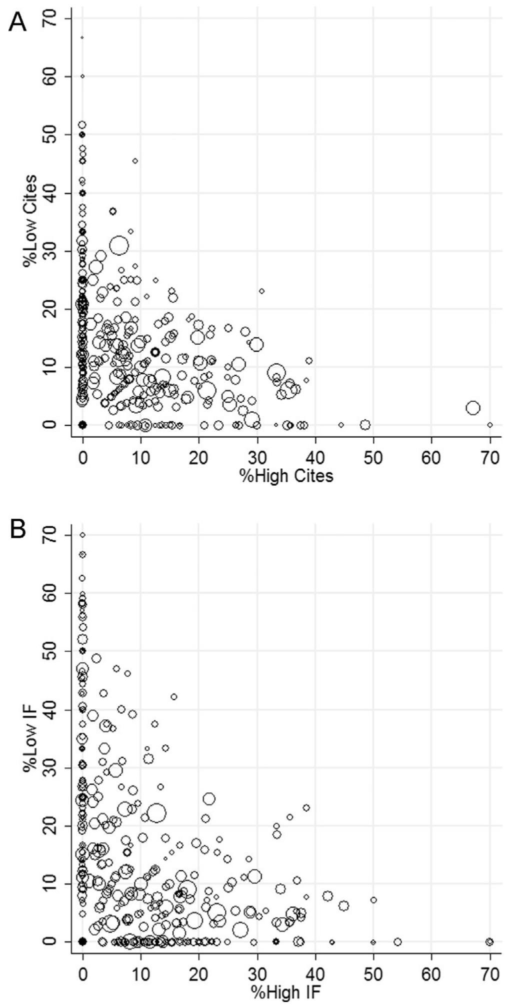


Fig. 1. Portfolio of publication impact at individual level.
[a] $N = 377$. The circle size represents the publication count of each respondent.

measured PIs' generation by the number of years since their first degree because the interviews suggested that publication practices may differ by generation (*#years since first degree*). We also control for gender (*female*). Since our data is cross-sectional, endogeneity is concerned. Among others, PI's performance should affect both our dependent and independent variables, causing an omitted variable bias. To mitigate this problem, we computed the impact portfolio measures for the five years before each PI obtained the tenured position (*pre-tenure %low cites*, etc.), with the expectation that these lagged variables capture unmeasurable factors including PI's performance. The descriptive statistics and correlation matrix of the variables are presented in Table 1.[21]

5.2. Description of publication portfolio

Fig. 1A and B illustrates the publication portfolio by plotting high vs. low-impact publications based on citation count and IFs, respectively. They suggest that approximately half of the PIs produce both high and low-impact publications. Thus, many academics who can publish high-impact papers simultaneously publish low-impact papers, which we suppose is partly attributed to policy designs as well as the probabilistic nature of scientific impact (Merton and Barber, 2004).

Table 1 shows the correlation between several publication types and impact portfolio at the individual level, and Appendix 2 further examines their association at the article level by regression analyses. The result suggests that industrial journals tend to be associated with higher IFs but not to citation count, and that clinical journals are negatively associated with high citations but not with low citations. The result also shows that on average 17% of papers are published in domestic journals, and that domestic publication is negatively correlated with impact both at the individual and article levels. In addition, 23% of publications are internationally coauthored, and they are positively associated with impact at both levels, as prior literature suggests (Narin et al., 1991). Finally, 16% of publications are first-authored by PhD students. These papers seem to be published in higher-IF journals, but when large percentages of papers are authored by students, the publication portfolio shifts toward lower impacts.

5.3. Regression result

Table 2 shows the regression results for the four dependent variables. In Table 2A, we first analyze the determinants of low-impact publications in terms of citation count and journal IF (Models 1–4 and 5–8, respectively). Models 1 and 5 are the base models; Models 2 and 6 control for the pre-tenure measures of the impact portfolio to mitigate endogeneity; Models 3 and 7 add variables for publication-type portfolios; and Models 4 and 8 control for IF for citation count and vice versa to examine if our independent variables operate primarily on citation (i.e., impact of research) or on IFs (i.e., journal choice). As to control variables, the coefficients of university rank are significantly negative, suggesting that organizational prestige affects publication impact. Gender shows no significant effect. PIs of older generations tend to produce lower-impact publications, consistent with the interview results.

To test the effects of resource allocation, we include the number of lab members and total research budget. The number of lab members does not show a significant effect in any model, but research budget shows strongly significant effects. The effect on %low-cites remains significant even after including all the control variables (Model 4: $b = -1.61$, $p < .01$), suggesting that a lack of budget leads to low-impact publications. On the other hand, the effect on %low-IF turns insignificant when publication types are controlled for (Model 7: $b = -.95$, $p > .1$). Taken together with correlation matrix (Table 1), this result implies that the effect on %low-IF is mediated by the choice of publication types. For example, studies publishable in industrial journals tend to cost more than purely academic research and those journals tend to have higher IFs. Further controlling for %low-cites, Model 8 shows that the budget effect almost disappears. Therefore, budget seems to work on the qualities of research (impact, appliedness, etc.) rather than journal choice.

Concerning career effects, inbreeding has no significant effect (except Model 7) though the signs of coefficient are consistent with our expectation. Foreign experience shows negative effects both for %low-cites and %low-IF (Model 1: $b = -.96$, $p < .05$; Model 5: $b = -2.33$, $p < .001$). This effect decreases but remains significant when pre-tenure portfolio measures are controlled for (Models 2 and 6). Then, controlling for publication types, Models 3 and 7 show that the effect further decreases. In particular, the effect on %low-cites diminishes (Model 3), implying that foreign experience decreases low-cited papers through frequent publications in clinical journals, infrequent publications in domestic journals, and frequent international coauthorship (cf. Table 1). On the other hand, the effect on %low-IF remains significant even after control-

240 billion JPY, among which 20 billion JPY was awarded to the top university (http://www.jsps.go.jp/j-grantsinaid/27_kdata/index.html). We ranked universities on the basis of the total funding for all fields because recent funding data for specific fields were not available. Although this has potential to introduce bias, we note that the ranking based on biology-related fields, which account for approximately half of the total funding, should be similar.

[21] The distributions of some variables are shown in Fig. S3 in Supplementary data.

Table 2
Prediction of impact-based publication portfolio.[a]

(A) Low-impact publication

	%Low cites								%Low IF							
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8	
Univ rank	−2.50***	(.71)	−2.48***	(.70)	−2.73***	(.71)	−1.88**	(.68)	−1.90*	(.91)	−2.05*	(.85)	−2.75***	(.73)	−1.80*	(.70)
Female	−.90	(4.16)	−.12	(4.10)	−1.12	(4.02)	.27	(3.80)	−4.60	(5.33)	−2.62	(4.98)	−3.64	(4.14)	−3.20	(3.90)
#Years since first degree	.29*	(.12)	.29*	(.12)	.23†	(.12)	.15	(.11)	.44**	(.16)	.34*	(.15)	.23†	(.12)	.15	(.12)
Pre-tenure %low cites			.13***	(.03)	.11**	(.03)	.08*	(.03)								
Pre-tenure %low IF											.25***	(.03)	.13***	(.03)	.11***	(.03)
%Low IF							.32***	(.05)								
%Low cites															.35***	(.05)
%Industrial journal					−.05*	(.02)	−.03	(.02)					−.05	(.03)	−.04	(.02)
%Clinical journal					−.06*	(.02)	−.01	(.02)					−.14***	(.03)	−.13***	(.02)
%Domestic journal					.09†	(.05)	−.06	(.05)					.43***	(.05)	.40***	(.05)
%International coauthorship					−.08†	(.04)	−.09*	(.04)					.05	(.04)	.07†	(.04)
%Student first author					−.04	(.05)	−.04	(.05)					.03	(.05)	.04	(.05)
Inbred	.14	(.18)	.10	(.18)	.15	(.18)	.05	(.17)	.22	(.24)	.23	(.22)	.31†	(.18)	.25	(.17)
Foreign experience	−.96*	(.48)	−.83†	(.47)	−.24	(.48)	.08	(.46)	−2.33***	(.61)	−1.75**	(.58)	−.90†	(.50)	−.81†	(.47)
#Member	.06	(.21)	.08	(.20)	.17	(.20)	.06	(.19)	.10	(.26)	.07	(.25)	.28	(.21)	.23	(.19)
Budget	−2.71***	(.57)	−2.66***	(.56)	−1.96***	(.58)	−1.61**	(.55)	−3.58***	(.73)	−2.95***	(.69)	−.95	(.60)	−.29	(.57)
F test	9.66***		1.39***		8.61***		12.23***		9.81***		16.69***		28.75***		33.45***	
Adjusted R^2	.140		.167		.209		.296		.141		.251		.491		.548	
N	375		375		375		375		375		375		375		375	

(B) High-impact publication

	%High cites								%High IF							
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8	
Univ rank	.91†	(.51)	.66	(.49)	1.14*	(.49)	.60	(.44)	1.34*	(.60)	.99†	(.57)	1.34*	(.57)	.71	(.51)
Female	−1.34	(2.97)	−.64	(2.83)	−.45	(2.76)	−1.31	(2.44)	1.34	(3.48)	.29	(3.29)	.73	(3.19)	1.60	(2.83)
#Years since first degree	−.36***	(.09)	−.30***	(.08)	−.27**	(.08)	−.09	(.08)	−.54***	(.10)	−.34**	(.10)	−.31**	(.10)	−.22*	(.09)
Pre-tenure %high cites			.14***	(.02)	.11***	(.02)	.06**	(.02)								
Pre-tenure %high IF											.17***	(.03)	.15***	(.03)	.08***	(.02)
%High IF							.41***	(.04)								
%High cites															.54***	(.05)
%Industrial journal					.01	(.02)	.00	(.02)					.04†	(.02)	.03†	(.02)
%Clinical journal					.03	(.02)	.02	(.02)					.02	(.02)	.00	(.02)
%Domestic journal					−.02	(.03)	.02	(.03)					−.10**	(.04)	−.09**	(.03)
%International coauthorship					.11***	(.03)	.06*	(.02)					.12***	(.03)	.06*	(.03)
%Student first author					−.06	(.04)	−.06†	(.03)					−.01	(.04)	.03	(.04)
Inbred	−.17	(.13)	−.16	(.13)	−.19	(.12)	−.15	(.11)	−.11	(.15)	−.05	(.15)	−.07	(.14)	.02	(.13)
Foreign experience	.08	(.34)	−.12	(.33)	−.56†	(.33)	−.58*	(.29)	.80*	(.40)	.44	(.38)	−.11	(.38)	.26	(.34)
#Member	.24	(.15)	.22	(.14)	.17	(.14)	.16	(.12)	.13	(.17)	.04	(.16)	−.02	(.16)	−.08	(.14)
Budget	2.81***	(.41)	2.64***	(.39)	2.34***	(.40)	1.45***	(.36)	2.91***	(.48)	2.72***	(.45)	2.19***	(.46)	.94*	(.43)
F test	18.67***		23.00***		17.17***		27.94***		16.15***		21.57***		16.92***		26.98***	
Adjusted R^2	.249		.320		.360		.502		.221		.306		.356		.493	
N	375		375		375		375		375		375		375		375	

[a] Unstandardized coefficients (standard errors in parentheses). Two-tailed test. $^{\dagger}p<.10$; $^{*}p<.05$; $^{**}p<.01$; $^{***}p<.001$. Ordinary least squares.

ling for %low-cites (Model 8: $b = -.81$, $p < .1$), suggesting that foreign experience may operate on journal choice, independent of research impact.

Table 2B runs the same set of regressions for high-impact publications. The results are somewhat different from Table 2A, so the determinants of low and high-impact publications are different. First, with all the control variables, foreign experience shows a significantly negative effect on %high-cites (Model 4: $b = -.58$, $p < .05$). Thus, with the same IF portfolio, returnees from foreign experience produce smaller percentages of high-cited papers than domestic academics. Second, foreign experience shows no significant effect on %high-IF (Model 8), suggesting that the effect of foreign experience on journal choice operates more on low-impact than on high-impact publications. As for resource allocation, the effect of budget is significantly positive both on %high-cites and on %high-IF, while the number of lab members shows no significant effect.

5.3.1. Concentrated resource allocation

Further to explore the effect of resource allocation, Table 3 adds the quadratic terms of resource variables to Models 3 and 7 of Table 2. Table 2 has suggested that a lack of budget increases low-impact publications in terms of citation count and IFs, but the effect of human resources is unclear. When including quadratic terms, the result indicates curvilinear effects both for budget and human resource allocation (Model 1 in Table 3A). The result suggests that %low-cites increases if a laboratory has 1.8 or more members (16% of our sample) or if a laboratory is awarded 75 million JPY or more (9.3% of our sample). Instead of simple lab size and budget variables, Models 2 uses the number of students per staff, and the amount of budget per member. The quadratic term of the latter is found significant. However, %low-cites starts to decline only when one member is awarded more than 16 million JPY, which is rather rare (1.5% of our sample). As in Table 2A, resource allocation does not affect %low-IF (Models 3 and 4).

As for high-impact publications (Table 3B), Model 1 does not show significant coefficients for the quadratic terms. Thus, the inefficiency due to resource overconcentration occurs mostly in low-impact publications. Models 2 and 4 indicate diminishing effects of budget allocation if one member is given about 18 million JPY or more, but this is uncommon. Model 4 also shows a significantly negative coefficient for the quadratic term of per-staff students, implying that one staff can efficiently take care of at most 1.5 PhD students (11% of our sample exceeds this threshold).

5.3.2. Mobile career design

To further investigate the career effect, we draw on a difference-in-difference (DiD) approach (Card and Krueger, 1994). For time-variant variables,[22] we computed the difference between the recent five years and the five years after graduation. For the international mobility effect, the treatment group is international returnees with foreign stay of one year or longer (67%) and the control group is domestic academics (33%).[23] Table 4A shows regression results on low-impact publications. For %low-cites, international mobility shows negative effect after controlling for publication types (Model 2: $b = -6.26$, $p < .05$), but it turns insignificant after including %low-cites (Model 3). On the other hand, international mobility consistently shows a negative effect on %low-IF (Models 4–6). This result implies that international mobility is more strongly associated with journal choice than with research impact. We run similar regressions for high-impact publications,[24] but the effect of international mobility is unclear, suggesting that foreign experience seems to primarily influence low-impact publications. These results are consistent with the interview result that international returnees tend to avoid publishing in low-IF journals.

For the inbreeding effect, we set respondents who stayed in the same university after graduation for 10 years or longer as the treatment group (21%) and those who left the university immediately after graduation as the control group (79%).[25] Table 4B shows regression results on low-impact publications. The result suggests that inbreeding increases low-cited publications (Model 2: $b = 6.94$, $p < .1$; Model 3: $b = 7.01$, $p < .05$), which is consistent with the interview results that inbred academics become risk-averse, but that low-IF publications are not affected (Models 4–6). The inbreeding effect on high-impact publications is similarly examined and insignificant.[26]

6. Discussion

The modern science is characterized by the publish-or-perish culture with a strong emphasis on publication performance. To investigate how the current policy trend influences academics' practices in publication, this study draws on in-depth interviews and econometric analyses of the questionnaire and bibliometric data of Japanese biologists.

First, this study examines the effect of resource allocation policies. With increasing pressure for accountability and budgetary constraint, resource allocation has become increasingly merit-based and competitive (Geuna and Martin, 2003; Hicks, 2012), which tends to cause unequal resource distribution (Hand, 2008; Shibayama, 2011). Our results show that a lack of resources leads to low-impact publications, consistent with prior findings of positive correlations between funding input and publication performance (Jacob and Lefgren, 2011; Zhao, 2010). However, our results also indicate that excessive resource input can compromise the publication impact. Academics with abundant resources might resort to mediocre ideas, or they might employ mass-production strategies without a thorough research design, resulting in inefficient use of resources. In addition, PIs of too large laboratories cannot spend enough time on supervising all members, and consequently some members may have to work on their projects with poor guidance (Salonius, 2008). From an individualistic perspective, expanding laboratories may be a rational strategy because it allows PIs to arrange a portfolio of many projects and mitigate the unpredictable nature of biological research. Furthermore, once PIs are accustomed to large resource input, they cannot easily downsize their laboratories. They may be reluctant to lay off members that have been trained. Large facilities entail operating cost in the long term. Then, PIs may prioritize maintaining a revenue over pursuing scientific excellence; i.e., they act more like a revenue-maximizer than a profit-maximizer (Sousa, 2008).

Second, this study investigates the effect of academic career policies. Policymakers have facilitated mobile career design and short-term employment, contending that mobility should facilitate scientific performance (EC, 2010; OECD, 2008) although empirical findings are rather mixed (Geuna, 2014). Our results support a negative effect of inbreeding on publication impact, consistent with Horta et al. (2010) and Inanc and Tuncer (2011). The interviews suggest that inbred academics may be satisfied with continuing their predecessor's research agenda, discouraged from exploring

[22] The measures for resource allocation are dropped because appropriate measures for the post-graduation period are unavailable.

[23] From this analysis, we drop respondents who stayed abroad before or within five years after graduation and those whose term of foreign experience was indeterminable.

[24] Table S4A in Supplementary data.

[25] From this analysis, we drop respondents who were inbred for shorter period than 10 years.

[26] Table S4B in Supplementary data.

Table 3
Effect of resource allocation.[a]

(A) Low-impact publication

	%Low cites				%Low IF			
	Model 1		Model 2		Model 3		Model 4	
Univ rank	−2.46***	(.71)	−2.84***	(.67)	−2.65***	(.74)	−2.57***	(.69)
Female	−1.22	(3.98)	−.48	(4.04)	−3.64	(4.14)	−3.59	(4.17)
#Years since first degree	.25*	(.12)	.22†	(.12)	.23†	(.12)	.23†	(.12)
Pre-tenure %low cites	.10**	(.03)	.11**	(.03)				
Pre-tenure %low IF					.13***	(.03)	.13***	(.03)
%Industrial journal	−.04†	(.02)	−.06*	(.02)	−.05*	(.03)	−.05*	(.03)
%Clinical journal	−.05*	(.02)	−.06*	(.03)	−.14***	(.03)	−.14***	(.03)
%Domestic journal	.09†	(.05)	.10*	(.05)	.43***	(.05)	.43***	(.05)
%International coauthorship	−.07†	(.04)	−.08†	(.04)	.05	(.04)	.05	(.04)
%Student first author	−.02	(.05)	−.03	(.05)	.04	(.05)	.04	(.05)
Inbred	.11	(.18)	.15	(.18)	.29	(.18)	.30	(.18)
Foreign experience	−.22	(.48)	−.15	(.48)	−.90†	(.50)	−.88†	(.50)
#Member	−.65	(.43)			.09	(.45)		
(#Member)^2	.03*	(.02)			.01	(.02)		
Budget	−5.04**	(1.80)			−2.57	(1.86)		
(#Budget)^2	.45*	(.23)			.23	(.23)		
#PhD/#staff			−.52	(2.39)			−.45	(2.47)
(#PhD/#staff)^2			−.43	(.77)			−.10	(.80)
Budget/#member			−1.35***	(.37)			−.53	(.38)
(Budget/#member)^2			.04**	(.01)			.02	(.01)
F test	8.22***		7.67***		24.95***		24.66***	
Adjusted R^2	.225		.211		.490		.487	
N	375		375		375		375	

(B) High-impact publication

	%High cites				%High IF			
	Model 1		Model 2		Model 3		Model 4	
Univ rank	1.09*	(.50)	1.86***	(.48)	1.28*	(.58)	1.83***	(.54)
Female	−.41	(2.76)	−.96	(2.87)	.73	(3.20)	.77	(3.23)
#Years since first degree	−.28***	(.08)	−.24**	(.09)	−.31**	(.10)	−.29**	(.10)
Pre-tenure %high cites	.11***	(.02)	.12***	(.02)				
Pre-tenure %high IF					.15***	(.03)	.15***	(.03)
%Industrial journal	.01	(.02)	.02	(.02)	.03†	(.02)	.04*	(.02)
%Clinical journal	.03	(.02)	.03†	(.02)	.02	(.02)	.02	(.02)
%Domestic journal	−.02	(.03)	−.05	(.03)	−.10*	(.04)	−.11**	(.04)
%International coauthorship	.11***	(.03)	.11***	(.03)	.12***	(.03)	.13***	(.03)
%Student first author	−.06†	(.04)	−.06	(.04)	−.01	(.04)	−.01	(.04)
Inbred	−.18	(.12)	−.19	(.13)	−.06	(.14)	−.06	(.14)
Foreign experience	−.57†	(.33)	−.62†	(.34)	−.12	(.38)	−.11	(.39)
#Member	.51†	(.30)			.14	(.35)		
(#Member)^2	−.01	(.01)			−.01	(.01)		
Budget	2.29†	(1.24)			2.91*	(1.44)		
(#Budget)^2	−.01	(.16)			−.10	(.18)		
#PhD/#staff			3.20†	(1.71)			3.40†	(1.91)
(#PhD/#staff)^2			−.57	(.55)			−1.10†	(.62)
Budget/#member			1.43***	(.26)			1.36***	(.30)
(Budget/#member)^2			−.04***	(.01)			−.04***	(.01)
F test	14.97***		12.56***		14.65***		14.11***	
Adjusted R^2	.359		.317		.354		.345	
N	375		375		375		375	

[a] Unstandardized coefficients (standard errors in parentheses). Two-tailed test. †$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$. Ordinary least squares.

Table 4
Difference-in-difference analysis for career effect.[a]

(A) International mobility and low-impact publication

	Δ%Low cites						Δ%Low IF					
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
ΔUniv rank	−.09	(1.00)	−.11	(.99)	−.51	(.95)	1.64	(1.29)	1.56	(1.14)	1.59	(1.09)
ΔYear (#years since degree)	.32	(.22)	.39†	(.22)	.28	(.21)	.20	(.28)	.44†	(.26)	.31	(.25)
Δ%Low IF					.26***	(.05)						
Δ%Low cites											.34***	(.07)
Δ%Industrial journal			−.04	(.03)	−.04	(.03)			−.03	(.04)	−.01	(.04)
Δ%Clinical journal			.00	(.04)	−.02	(.04)			.04	(.04)	.04	(.04)
Δ%Domestic journal			.15***	(.04)	.04	(.04)			.40***	(.05)	.35***	(.05)
Δ%International coauthorship			.02	(.06)	.00	(.06)			.07	(.07)	.07	(.07)
Returnee (=1) vs. domestic (=0)	−6.38*	(2.69)	−6.26*	(2.67)	−3.86	(2.61)	−9.27**	(3.45)	−9.36**	(3.09)	−7.21*	(2.99)
F test	2.21†		3.18**		5.97***		2.98*		12.33***		14.72***	
Adjusted R^2	.014		.057		.137		.023		.240		.304	
N	252		252		252		252		252		252	

(B) Inbreeding and low-impact publication

	Δ%Low cites						Δ%Low IF					
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
ΔUniv rank	−.19	(1.21)	−.49	(1.20)	−1.03	(1.15)	2.39	(1.50)	1.92	(1.34)	2.09	(1.27)
ΔYear (#years since degree)	.28	(.28)	.37	(.28)	.24	(.27)	.26	(.35)	.46	(.32)	.33	(.30)
Δ%Low IF					.28***	(.06)						
Δ%Low cites											.35***	(.08)
Δ%Industrial journal			−.03	(.04)	−.02	(.04)			−.05	(.05)	−.04	(.05)
Δ%Clinical journal			−.02	(.05)	−.03	(.05)			.04	(.05)	.05	(.05)
Δ%Domestic journal			.16**	(.05)	.05	(.05)			.41***	(.06)	.35***	(.05)
Δ%International coauthorship			−.03	(.08)	−.05	(.07)			.06	(.09)	.07	(.08)
Inbred (=1) vs. outbred (=0)	5.74	(3.85)	6.94†	(3.83)	7.84*	(3.65)	−6.38	(4.77)	−3.20	(4.29)	−5.66	(4.12)
F test	1.17		2.40*		4.80***		1.45		8.89***		11.08***	
Adjusted R^2	.003		.050		.140		.007		.228		.301	
N	188		188		188		188		188		188	

[a] Unstandardized coefficients (standard errors in parentheses). Two-tailed test. $^{\dagger}p<.10$; $^{*}p<.05$; $^{**}p<.01$; $^{***}p<.001$. Ordinary least squares. Regressions on high-impact publications are shown in Table S4 in Supplementary data.

their original research topics. Consistently, the econometric analyses suggest that inbred academics produce higher percentages of low-cited papers than outbred academics. Among various forms of mobility, international mobility has been popular as a means to facilitate global competitiveness (Stephan, 2012). In the case of Japan, the majority of foreign experience occurs in the US and internationally mobile academics usually return home (Franzoni et al., 2014). This study finds that international mobility is associated with higher publication impact, consistent with prior literature (Franzoni et al., 2014). The interviews suggest that engagement in international academic network improves research quality, and more interestingly, that foreign experience can affect publication norms and strategies. In particular, our results indicate that returnees are unwilling to publish in low-IF journals. Academics might have learned to pay a greater attention to publication destination during their stay in the US (Hamermesh and Pfann, 2012). A supplementary analysis implies that lower percentages of low-IF publications are achieved not by making a greater effort for higher-IF publications, but by simply reducing low-IF publications.[27] Thus, as the interviewees mentioned, returnees may tend to abandon papers that are rejected or likely to be rejected by high-impact journals.

Our results offer a few policy implications. Concerning resource allocation, excessive concentration can compromise scientific impact, so more equal distribution of budgets and human resources can improve overall impact. As for academic career design, inbreeding is found to be associated with low impact, supporting current pro-mobility policies. However, the results imply that international mobility can affect publication practices in that academics, through foreign stay with intense pressure for publication, learn to avoid publications that are unlikely to be rewarded (i.e., publications in low-IF journals). Since papers published in low-IF journals can still offer some scientific contribution, excessive emphasis on publication impact can contradict the norm of open science. Overall, this study suggests that impact-oriented policies, if poorly designed or managed, could actually compromise publication impact, and thus, calls for rethinking the possible downsides of current science policies.

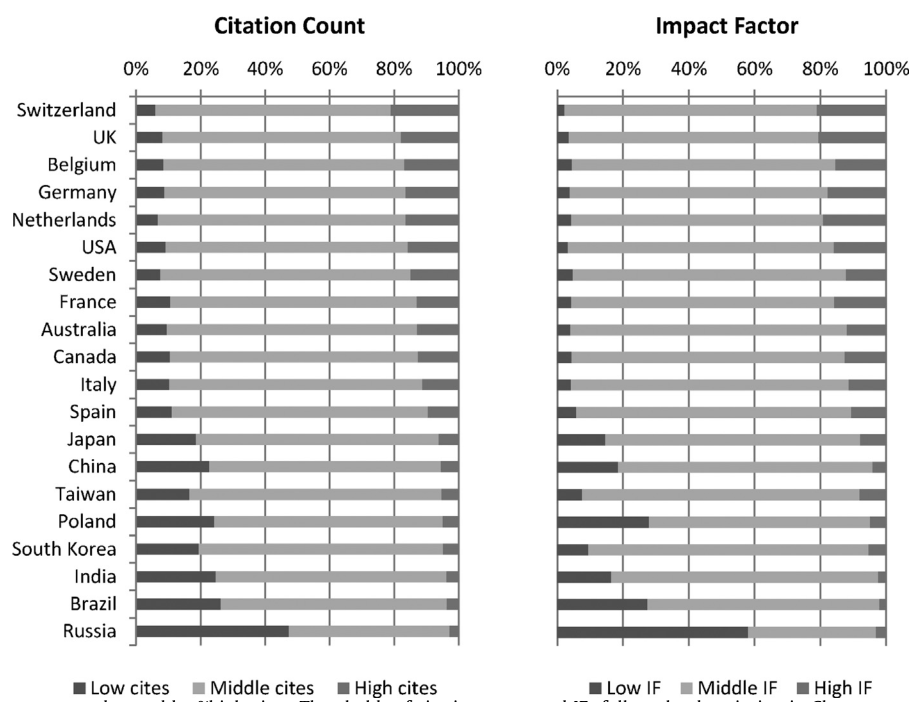
Our results need to be interpreted with reservations about some limitations. One obvious limitation is the sample specificity in terms of the country and scientific field. Though we believe that the focal policies are fairly common, further research is needed for generalization. Second, we draw on two sets of dependent variables based on citation count and IFs, but both measures have limitations and require careful interpretation (e.g., Macroberts and Macroberts, 1996; Redner, 1998; Weingart, 2005). Third, we cannot fully address the endogeneity for regression analyses. We attempt to mitigate the problem by the DiD approach and so forth, but future research is needed for a more sophisticated econometric approach.

Acknowledgments

We acknowledge Paul David, Miho Funamori, David N. Laband, John P. Walsh, and three anonymous referees for constructive comments. We also acknowledge 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 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.

Appendix 1.

Portfolio of publication impact by country in biochemistry & molecular biology.[a]



[a]The top 20 countries are chosen based on the publication count and sorted by %high-cites. Thresholds of citation count and IFs follow the description in Chapter 5.1.1. 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. Nationality is determined based on authors' address (AD).

[27] Internationally mobile academics tend to publish fewer papers than domestic academics (Table S5 in Supplementary data).

Appendix 2.

Prediction of publication impact at article level.[a]

	Model 1		Model 2		Model 3		Model 4	
	Low cites		Low IF		High cites		High IF	
ln (#Authors)	−.093	(.067)	−.023	(.083)	−.008	(.073)	−.170*	(.071)
ln (#Author organizations)	−.163*	(.082)	−.415***	(.108)	.653***	(.091)	.746***	(.087)
Industrial journal	−.084	(.097)	−.299*	(.131)	.118	(.095)	1.082***	(.101)
Clinical journal	.065	(.107)	.091	(.157)	−.516***	(.101)	−.195*	(.097)
Domestic publisher	.982***	(.101)	3.408***	(.124)	−1.268***	(.218)	−17.496	(572.583)
International coauthor	−.373**	(.118)	.051	(.142)	.326**	(.099)	.467***	(.095)
Student first author	−.151	(.108)	−.340*	(.138)	−.172	(.122)	.285**	(.108)
F test	148.47***		1153.41***		222.12***		500.94***	
Observation	6586		5626		5473		6175	
N	284		221		202		239	

[a]Unstandardized coefficients (standard errors in parentheses). Two-tailed test. $^{\dagger}p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. Logit regression with fixed-effects of individual academics. Though we have 377 academics, some of them are dropped from regressions due to a lack of variation in the dependent variable given a set of independent variables. Independent variables are measured as follows. The numbers of authors and author organizations are counted based on the author information, and we take their logarithms. Other five variables are all dummies prepared based on the same sources as explained for the individual-level portfolio measurements (Chapter 5.1.2).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.respol.2015.01.012.

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