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**Temporal trends in academic performance and career duration of principal investigators in ecology and evolutionary biology in Taiwan**

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**Abstract**

Academic job markets have become increasingly challenging worldwide, with rising performance requirements for recruitment as a new faculty member and promotion to full professor in recent years. However, it remains underexplored how research performance and other determinants of academic success, including PhD university origin, prestige, and gender, affect recruitment and promotion over time. Focusing on the field of ecology and evolutionary biology in Taiwan, we analyzed the academic performance (measured as h-index) as well as the duration before recruitment and promotion of 145 principal investigators (PIs) over the past 34 years. We found that the performance of PIs before recruitment and before promotion both increased in recent years, and male PIs had on average higher performance than female PIs before recruitment. Moreover, the career duration before recruitment and before promotion both increased in recent years. PIs with Taiwanese PhD degrees tended to have longer duration before recruitment, yet higher performance shortened the duration. PhD university ranking had no effect on performance and duration either before recruitment or before promotion. We also found that PIs recruited in recent years exhibited a performance drop post-recruitment. Furthermore, PIs with Taiwanese PhD degrees appeared to show a decrease in performance after promotion compared to those with foreign degrees. Taken together, our study reveals increased academic performance and career duration of PIs in ecology and evolutionary biology in Taiwan over the last three decades, and highlights the crucial role of research performance, rather than the PhD prestige itself, in determining academic success.

**Keywords**

academic job market, academic performance, career duration, h-index, principal investigator, publication

**Introduction**

The academic job market has been increasingly competitive in many fields of science, technology, engineering, and mathematics (STEM) (Cyranoski et al. 2011; Ghaffarzadegan et al. 2015; Xue and Larson 2015), with more PhDs produced but vacancies for tenure-track academic positions remaining relatively constant over the past four decades (Larson et al. 2014; Schillebeeckx et al. 2013). For example, in the US, only 7.6% of new PhDs in life sciences landed tenure-track positions within three years after graduation in 2010. Such a surplus of PhD supply has also emerged in other STEM fields (National Science Foundation 2018).

The intensified competition for tenure-track positions, due to disproportionately high numbers of applicants per position (Larson et al. 2014), has resulted in higher expectations for academic performance shaped by a *“publish or perish”* culture (Garfield 1996). A survey of evolutionary biologists recruited as junior researchers at the National Centre for Scientific Research (CNRS) in France showed that academics recruited in 2013 published nearly twice as many papers as those recruited in 2005 did (Brischoux and Angelier 2015). Furthermore, although the minimum education requirement for a tenure-track position is having a PhD degree, it has become increasingly frequent for applicants to have one or even more postdoctoral appointments. Consequently, many PhDs in STEM work as postdoctoral researchers for a prolonged period of time and wait for future opportunities until they are competitive enough in the academic job markets (Swihart et al. 2016), whereas some turn to alternative careers outside academia. In the aforementioned CNRS example, Brischoux and Angelier (2015) also found that the time between first publication and recruitment had increased from 3.25 to 8.0 years. The increase in postdoctoral training time can be detrimental to not only the scientific community but also individuals because this increases the age at which researchers become independent, and they have to trade off families for research, with fixed-term and relatively low-paying jobs (Acton et al. 2019).

As the number of applicants largely surpasses the available faculty positions, understanding what factors contribute to a researcher’s success in the increasingly competitive academic job market has become the center of attention. Among the determinants of academic excellence and career success, research performance is arguably the most critical one (Danell 2011, Acuna et al. 2012, van Dijk et al. 2014). Researchers with more publications, in particular highly cited and top journal publications, tend to be more successful in their long-term careers (Lindahl 2018, Hou et al. 2022). Moreover, researchers having more first author publications and publishing more in top journals have higher h-indexes and are more likely to become principal investigators (PIs) (van Dijk et al. 2014). Research performance is crucial for academic success as publication requirements for recruitment as a new faculty member and promotion to full professor have surged in recent years. Yet, empirical quantification of how research performance affects researchers’ career duration for recruitment and promotion over time remains unexplored.

In addition to research performance, the prestige of doctoral-granting institutes can influence academic employment as well (van Dijk et al. 2014). Higher doctoral prestige is associated with increased rates of recruitment success and better faculty placement (Clauset et al. 2015). In East Asian countries, the initiative to build world-class universities has led many universities to preferentially recruit returnees who obtained PhD degrees from top-ranked universities in Western countries (Shin and Kehm 2013). Hence, competition for limited tenure-track positions is exacerbated when foreign PhDs are favored, leaving domestically-trained PhDs deprived of career development opportunities (Chen 2021). However, whether and to what extent publication performance and career duration differ between researchers with domestic and foreign degrees, and whether their pre- and post-employment performance changes, remain largely unclear.

Gender is another determinant of research performance and career success across STEM fields (Larivière et al. 2013, Huang et al. 2020). For example, studies have shown that male researchers have higher publication rates, receive more citations, and make greater scientific impacts compared to their female counterparts (Symonds et al. 2006, West et al. 2013, McDermott et al. 2018, but see Huang et al. 2020). Moreover, males have a higher probability of becoming PIs (van Dijk et al. 2014) and often land positions at higher-ranked institutions than females (Clauset et al. 2015). Yet, despite the well-documented gender gaps in research outputs and academic job market success, little is known about the gender differences in career duration, that is, whether the time to land a faculty position and to get a promotion differs between male and female researchers.

To address these gaps, we investigated how academic performance as well as duration before recruitment as a new PI and promotion to full professor changed over time, and how PhD university origin, PhD university ranking, and gender affected the career success of PIs, in the field of ecology and evolutionary biology in Taiwan. Specifically, we examined the following questions: (1) Is the academic performance of PIs before recruitment/promotion associated with the year of recruitment/promotion, PhD university origin, ranking, and gender? (2) Is the duration before recruitment/promotion associated with the year of recruitment/promotion, academic performance, PhD university origin, ranking, and gender? (3) Do the year of recruitment/promotion, PhD university origin, ranking, and gender affect the difference in academic performance before and after recruitment/promotion? We aim to provide empirical evidence illustrating the temporal trends in researchers’ publication performance and the time required to land a faculty position or get a promotion, as well as to explore the role of PhD degree and gender in determining the success of academic employment and promotion.

**Materials and Methods**

*Data collection*

Between November and December, 2021, we surveyed tenure-track faculty members at seven universities in Taiwan, all of which were qualified as research-intensive universities and ranked top 150 in Asia according to 2022 QS Asia University Rankings (https://www.topuniversities.com/). We also surveyed academics from Academia Sinica, a leading academic institution in Taiwan. We defined the field of ecology and evolutionary biology based on the scope of the journal *Ecology and Evolution* (https://onlinelibrary.wiley.com/journal/20457758), which encompasses research on micro and macro evolutionary processes, individuals’ physiological responses to the environment, population genetics and phylogenetics, systematics and taxonomy, organisms’ behavior, species abundance and distribution, species interactions, community and ecosystem dynamics, and biodiversity and conservation.

To identify the PIs for our analyses, we first generated a list of biology-related departments/divisions at the eight top-ranked universities/institutes in Taiwan, which consisted of a total of 81 departments/divisions. We then excluded those departments/divisions that focus primarily on biomedical sciences, leaving 33 departments/divisions after this filtering. For these 33 departments/divisions, we visited the websites and recorded PIs whose areas of research and publications fell within our definition of ecology and evolutionary biology. A total of 145 PIs with an updated curriculum vitae online (e.g., institutional/personal websites or Open Researcher and Contributor ID [ORCID]) were identified in our survey. For each PI, we recorded information on the university and year of PhD completion, year of recruitment as a new PI, year of promotion to full professor (only for PIs who were full professors), and gender. The university ranking was determined based on 2022 QS World University Rankings. The duration before recruitment as a new PI was calculated as the time between PhD completion and landing a faculty position; the duration before promotion to full professor was calculated as the time between landing a position and getting a promotion.

We collected citation data of PIs via the *Publish or Perish* software, which uses Google Scholar Profiles queries to obtain citation information of researchers’ publications and converts it into several citation metrics (e.g., total number of citations, citations per year, and h-index). The data collection was conducted at the author level by entering each PI’s full name or the abbreviated version in scientific publications to the search field. The range of years was set based on the year of recruitment and promotion for each PI (five-year interval before and after the year of recruitment/promotion; see the following section *Measurement of academic performance* for more details). After the search was completed, we checked individually each publication item in the results pane and included only peer-reviewed papers and book chapters regardless of authorship (PhD theses and conference presentations were excluded). Duplicate items were also removed from the search results. The final citation metrics were then exported for further statistical analyses.

We performed citation searches via Google Scholar Profiles because it is freely available and thus more transparent for tenure reviews (Pauly and Stergiou 2005). Moreover, its high coverage allows researchers to obtain comprehensive bibliometric data (Martín-Martín et al. 2021). A major limitation of Google Scholar Profiles is that the metadata for publications (e.g., publication type and DOI) are relatively limited compared to other search engines such as Web of Science or Scopus (Martín-Martín et al. 2018) (also see Martín-Martín et al. [2018] for detailed comparisons of the strengths and weaknesses of various academic search engines for bibliometric analyses). This limitation is not a major concern for our study because we did not use such metadata in our analyses.

*Measurement of academic performance*

We used h-index as a measurement of academic performance (Hirsch 2005), a widely accepted metric that incorporates the assessment of publication quantity (number of publications) and quality (number of citations) (Glänzel 2006). In fact, the number of publications and citations were both highly correlated with h-index in our study (number of publications: *r* = 0.91, *P* < 0.001; number of citations: *r* = 0.77, *P* < 0.001) (such high correlations have also been reported in previous studies, e.g., Laurance et al. [2013] and Ryan Haley [2012]). Furthermore, h-index is robust to a few highly-cited or a set of lowly-cited publications, rending it suitable for evaluating the overall impact of a researcher’s outputs (Bornmann and Daniel 2007). Although h-index can vary considerably among different fields of study (Alonso et al. 2009), we focused on PIs within the field of ecology and evolutionary biology and thus their h-indexes should be fairly comparable.

We calculated h-index within the five-year interval both before and after the year of recruitment and promotion, generating up to four h-indexes for each PI (some PIs might have only one to three such h-indexes depending on their current stages). We used the duration of five years because this time span is commonly used by institutes to evaluate the most recent academic performance both for recruiting a new PI and for promotion to full professor. The publications and citations during the year of recruitment and promotion were considered as the performance before recruitment and promotion because these publications, either as published papers or manuscripts “accepted” or “in press”, would most likely contribute to the evaluation of academic performance prior to successful recruitment and promotion. For example, a PI who started a position in 2010 would have an h-index measured for publications between 2006 and 2010 (i.e., “Before” h-index for recruitment), and another h-index measured for publications between 2011 and 2015 (i.e., “After” h-index for recruitment). We did not compute “After” h-index for PIs who were recruited or promoted less than five years (as of 2022) so that the h-indexes for all PIs in our analyses were comparable.

*Statistical analyses*

1. Academic performance before recruitment/promotion (Model 1 and 2)*.* To examine how various factors affect the academic performance before recruitment as a new PI and promotion to full professor, we fit generalized linear mixed models (GLMMs) (Bolker et al. 2009) with the “Before” h-index for recruitment/promotion as the response, year of recruitment/promotion, PhD university origin (Taiwan vs. Foreign), PhD university ranking, and gender (Male vs. Female) as fixed effects, and the institute (department) nested within university as random effects. Model 1 was fitted with a negative binomial error distribution and a log link function as the response is non-negative integers with significant overdispersion (*χ2* = 199.59, *df* = 130, *P* < 0.001); Model 2 was fitted with a Poisson error distribution and a log link function as no significant overdispersion was detected (*χ2* = 64.01, *df* = 51, *P* = 0.10).
2. Duration before recruitment/promotion (Model 3 and 4). To examine how various factors affect duration before recruitment and promotion, we fit GLMMs with the duration before recruitment/promotion as the response, the “Before” h-index for recruitment/promotion, year of recruitment/promotion, PhD university origin (Taiwan vs. Foreign), PhD university ranking, and gender (Male vs. Female) as fixed effects, and the institute (department) nested within university as random effects. Both Model 3 and 4 were fitted with a Poisson error distribution and a log link function as the response is non-negative integers without significant overdispersion (Model 3: *χ2* = 149.58, *df* = 125, *P* = 0.07; Model 4: *χ2* = 32.98, *df* = 47, *P* = 0.94).
3. Difference in academic performance before and after recruitment/promotion (Model 5 and 6). To examine how various factors affect the difference in academic performance before and after recruitment/promotion, we fit linear mixed-effects models (LMMs) (Bolker et al. 2009) with the difference between “After” and “Before” h-index for recruitment/promotion (“After” h-index minus “Before” h-index) as the response, year of recruitment/promotion, PhD university origin (Taiwan vs. Foreign), PhD university ranking, and gender (Male vs. Female) as fixed effects, and the institute (department) nested within university as random effects. The LMMs were fitted with a Gaussian error distribution and an identity link function.

A total of six models (four GLMMs and two LMMs) were performed using the glmer()/lmer() function in the “lme4” package (Bates et al. 2015). Only full observations were used in each model (observations with any missing entry were omitted; see Table 1 for the actual sample size for each model). The assumption of equal variance and normality were assessed using residual plots and QQ-plots. Significance (α = 0.05) of model coefficients were tested (Wald chi-square test) using the Anova() function in the “car” package (Fox and Weisberg 2019). All analyses were performed in R version 4.2.2 (R Development Core Team 2022).

**Results**

Our final data included a total of 145 tenure-track faculty members recruited between 1987 and 2021, of which 44.8% were full professors, 24.8% were associate professors, and 30.3% were assistant professors. Nearly half of the PIs obtained their PhD degrees from the USA (45.5%), followed by Taiwan (33.1%), and relatively few from the UK (4.8%) and other countries (Fig. 1). The PhD universities varied widely in the ranking of prestige among 73 universities from 16 countries (Fig. 2). The gender difference was substantial, with males (112) being around four times as many as females (33).

*Academic performance before recruitment/promotion*

The academic performance before recruitment (“Before” h-index for recruitment) was higher for PIs who landed tenure-track positions more recently (Model 1; Table 1, Fig. 3a). Similarly, the performance before promotion to full professor (“Before” h-index for promotion) was higher for PIs who got promoted more recently (Model 2; Table 1, Fig. 3b), though the rate of increase was lower compared to that before recruitment (*β* for recruitment vs. promotion: 0.040 vs. 0.005; Table 1). Male PIs had on average higher performance than female PIs before recruitment, while no such gender difference was found before promotion (Model 1 and 2; Table 1). PhD university origin and ranking had no significant effect on the performance either before recruitment or before promotion (Model 1 and 2; Table 1).

*Duration before recruitment/promotion*

PIs who landed positions more recently spent more time post-PhD before recruitment (Fig. 3c). PIs with Taiwanese PhD degrees tended to have longer durations before recruitment, while higher academic performance appeared to reduce this duration, although not statistically significant (Model 3; Table 1). PIs also spent more time before promotion to full professor in recent years (Fig. 3d), yet the duration was not related to the performance or the PhD university origin (Model 4; Table 1). PhD university ranking and gender had no significant effect on the duration either before recruitment or before promotion (Model 3 and 4; Table 1).

*Difference in academic performance before and after recruitment/promotion*

The difference in academic performance before and after recruitment (“After” h-index minus “Before” h-index) decreased for PIs who landed positions more recently (Fig. 4a); PhD university origin, ranking, and gender had no effect on the performance difference (Model 5; Table 1, Fig. 4b). The difference in performance before and after promotion to full professor, although not statistically significant, also decreased over years (Fig 4c). Moreover, the difference tended to be higher for PIs with foreign degrees compared to those with Taiwanese degrees (Fig. 4d). PhD university ranking and gender had no significant effect on the performance difference (Model 6; Table 1, Fig. 4d).

**Discussion**

Overall, we found that the academic performance of PIs before recruited as new faculty members as well as before promoted to full professors both increased over years. We also showed that the career duration before recruitment and before promotion has both increased in recent years. These results provide empirical evidence supporting the speculation that publication requirements and expectations have risen over time in the field of ecology and evolutionary biology in Taiwan, in line with many academic job markets worldwide (Rawat and Meena 2014; Warren 2019).

The increase in academic performance of PIs before recruitment suggests that the academic job market might have become increasingly competitive over time, which is likely driven by a relatively lower demand for tenure-track professors compared to the supply of new PhDs (Larson et al. 2014). Consequently, the duration post-PhD may be prolonged if the applicants are not competitive enough. Furthermore, PIs with Taiwanese PhD degrees tended to have longer duration before recruitment, which likely resulted from employment institutes favoring candidates with foreign degrees. However, higher academic performance shortened the time to land a position. Therefore, it would be beneficial for early-career researchers to hone in on publications in order to demonstrate their competence for academic success.

The performance of PIs before promotion to full professor also increased over years, but the rate of increase was lower than that during recruitment, indicating that the publication requirements for promotion might not have changed much over time compared to the requirements for recruitment. Interestingly, the time to full professor has lengthened in recent years, yet higher academic performance did not shorten the duration as it did during the recruitment phase. This may be partly due to increasing consideration of accomplishments such as teaching and administrative services by employment institutes in addition to research outputs. Overall, the differences in the temporal patterns of academic performance and career duration between recruitment and promotion phase are likely due to the nature of recruitment and promotion process: applicants are facing increasing competition with others during recruitment and thus higher performance would be advantageous for securing a position faster, whereas getting a promotion depends mainly on individual PI meeting the institutes’ requirements rather than comparing against others’ performance and thus higher performance may have less impact on promotion.

We found that the average performance of a new male PI was higher than that of a new female PI. This may result from higher standards for evaluating the suitability of a potential faculty member for males compared to females (Symonds et al. 2006). Alternatively, it could be due to employment institutes striving to recruit female applicants to enhance gender equity despite the likelihood of female applicants having lower performance than their male competitors, which can be exacerbated by implicit bias and stereotype threats that females face in biological sciences (Salerno et al. 2019). In contrast, the performance expectations for promotion to full professor did not differ between male and female PIs, suggesting that individual performance is the key to further promotion after recruitment regardless of gender, especially when gender equality is enhanced.

Contrary to a previous study showing that researchers from higher-ranked institutes became PIs faster compared to those from lower-ranked institutes (van Dijk et al. 2014), we found no evidence of PhD university ranking influencing the career duration either before recruitment or before promotion. Instead, our results suggest that academic performance during PhD and/or post-PhD period may be more important in determining the academic success compared to the prestige of education itself.

The difference in performance before and after recruitment decreased over years. Specifically, PIs in earlier years had on average higher h-indexes after recruitment than before recruitment, yet such a “performance boost” has declined recently. This could result from increasing teaching and administrative loading of new PIs in recent years, which may have reduced their available time for research. Moreover, PIs with Taiwanese PhD degrees appeared to show a decrease in performance after promotion to full professor compared to before promotion, whereas PIs with foreign PhD degrees had relatively consistent performance before and after promotion. A possible explanation is that the training and experiences from foreign universities may have equipped those PIs with greater professional abilities, which together with international connections and collaboration opportunities, help maintain their performance.

It is noteworthy that recruitment is a complicated process involving not only academic performance *per se* but also other considerations such as the suitability of applicants to the research areas of opening positions. Although our study showed increasing academic performance expectations for recruitment over years, we do not intend to discourage the academic community with such results. Indeed, variations in h-index during recruitment phase indicate that it is still possible for an applicant with a relatively low h-index to land a position. Moreover, besides research performance, other aspects of academic achievements, including teaching, mentoring, and social outreach, also constitute a significant part of a researcher’s career, and we stress that balancing these different aspects would be necessary for a more holistic professional development. Finally, our analyses were based on PIs in ecology and evolutionary biology, within which variations in publication performance and citation patterns may exist. Since the nature of academic job markets can vary considerably among different sub-fields of biology (Larson et al. 2014), the results herein should be interpreted carefully when applied to the fields outside the scope of this study.

Taken together, our study confirms that succeeding in academia has become more challenging, with performance requirements and career duration both increasing over years. Based on our findings, we provide several suggestions for people who hope to pursue an academic career and who are progressing through their career stages: (1) For PhD students and early-career researchers, focusing on research performance may facilitate future academic success, but other aspects of academics (e.g., scientific communication and networking) are important as well. (2) For researchers who have landed a position, fulfilling institute’s requirements while maintaining academic outputs may accelerate the promotion process. (3) For researchers with domestic degrees, seeking international collaboration to expand research network may help enhance productivity. Finally, regardless of career stage, boosting performance is the ultimate key to academic success in the face of increasingly competitive academic job markets.

**Statements and Declarations**

* **Competing interests**

The authors declare no competing interests.

* **Footnotes**

Please note that this manuscript has also been posted on *bioRxiv* (Hsu et al. 2022) at https://www.biorxiv.org/content/10.1101/2022.01.31.478501v2, following the Springer Nature preprint sharing policy. It has also been added to the reference list.

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* **Authors’ contributions**

G.-C.H. and S.-J.S. conceived the study; W.-J.L. and S.-J.S. collected the data; G.-C.H. and S.-J.S. analyzed the data. All authors were involved in writing the manuscript.

**References**

Acton, S.E., Bell, A.J., Toseland, C.P. & Twelvetrees, A. (2019). A survey of new PIs in the UK. *eLife*, 8.

Acuna, D. E., Allesina, S. & Kording, K. P. (2012). Predicting scientific success. *Nature*, 489, 201-202.

Alonso, S., Cabrerizo, F. J., Herrera-Viedma, E. & Herrera, F. (2009). h-Index: A review focused in its variants, computation and standardization for different scientific fields. *Journal of informetrics*, 3, 273-289.

Bates, D., Maechler, M., Bolker, B. & Walker, S. (2015). *Fitting linear mixed-effects models using lme4*. *R package version*.

Bolker, B. M., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Stevens, M. H. H., & White, J. S. S. (2009). Generalized linear mixed models: a practical guide for ecology and evolution. *Trends in ecology & evolution*, *24*, 127-135.

Bornmann, L. & Daniel, H. D. (2007). What do we know about the h index?. *Journal of the American Society for Information Science and technology*, 58, 1381-1385.

Brischoux, F. & Angelier, F. (2015). Academia’s never-ending selection for productivity. *Scientometrics*, 103, 333–336.

Chen, N. (2021). “Why should a ‘foreigner’ be better than me?”: preferential practices in junior academic faculty recruitment among mainland Chinese universities. *Tertiary Education and Management*, 1–25.

Clauset, A., Arbesman, S. & Larremore, D. B. (2015). Systematic inequality and hierarchy in faculty hiring networks. *Science advances*, 1, e1400005.

Cyranoski, D., Gilbert, N., Ledford, H., Nayar, A. & Yahia, M. (2011). Education: The PhD factory. *Nature*, 472, 276–279.

Danell, R. (2011). Can the quality of scientific work be predicted using information on the author's track record?. *Journal of the American Society for Information Science and Technology*, 62, 50-60.

Fox J. & Weisberg, S. (2019). An R Companion to Applied Regression, 3rd edn. Sage, Thousand Oaks CA.

Garfield, E. (1996). What Is The Primordial Reference For The Phrase “Publish Or Perish”? *The Scientist*, 10, 11.

Ghaffarzadegan, N., Hawley, J., Larson, R. & Xue, Y. (2015). A Note on PhD Population Growth in Biomedical Sciences. *Systems Research and Behavioral Science*, 32, 402–405.

Glänzel, W. (2006). On the h-index - A mathematical approach to a new measure of publication activity and citation impact. *Scientometrics 2006 67:2*, 67, 315–321.

Hirsch, J.E. (2005). An index to quantify an individual’s scientific research output. *Proceedings of the National Academy of Sciences*, 102, 16569–16572.

Hou, L., Wu, Q. & Xie, Y. (2022). Does early publishing in top journals really predict long-term scientific success in the business field?. *Scientometrics*, 127(11), 6083-6107.

Hsu, G.C., Lin, W.J. & Sun, S.J. Increased academic performance and prolonged career duration among Taiwanese academic faculty in ecology and evolutionary biology. *bioRxiv*, doi: https://doi.org/10.1101/2022.01.31.478501.

Huang, J., Gates, A. J., Sinatra, R. & Barabási, A. L. (2020). Historical comparison of gender inequality in scientific careers across countries and disciplines. *Proceedings of the National Academy of Sciences*, 117, 4609-4616.

Larivière, V., Ni, C., Gingras, Y., Cronin, B. & Sugimoto, C. R. (2013). Bibliometrics: Global gender disparities in science. *Nature*, 504, 211-213.

Larson, R.C., Ghaffarzadegan, N. & Xue, Y. (2014). Too many PhD graduates or too few academic job openings: The basic reproductive number R0 in academia. *Systems Research and Behavioral Science*, 31, 745–750.

Laurance, W.F., Useche, D.C., Laurance, S.G. & Bradshaw, C.J.A. (2013). Predicting Publication Success for Biologists. *BioScience*, 63, 817–823.

Lenth, R. v. (2021). emmeans: Estimated marginal means, aka least-squares means. R package version 1.7.1. *R Foundation for Statistical Computing*.

Lindahl, J. (2018). Predicting research excellence at the individual level: The importance of publication rate, top journal publications, and top 10% publications in the case of early career mathematicians. *Journal of Informetrics*, 12, 518-533.

Martín-Martín, A., Orduna-Malea, E., Thelwall, M. & López-Cózar, E. D. (2018). Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. *Journal of informetrics*, 12, 1160-1177.

Martín-Martín, A., Thelwall, M., Orduna-Malea, E. & Delgado López-Cózar, E. (2021). Google Scholar, Microsoft Academic, Scopus, Dimensions, Web of Science, and OpenCitations’ COCI: a multidisciplinary comparison of coverage via citations. *Scientometrics*, 126, 871-906.

McDermott, M., Gelb, D. J., Wilson, K., Pawloski, M., Burke, J. F., Shelgikar, A. V., & London, Z. N. (2018). Sex differences in academic rank and publication rate at top-ranked US neurology programs. *Jama Neurology*, 75, 956-961.

National Science Foundation. (2018). *Science and Engineering Indicators*. *NSB-2018-1*. Available at: https://www.nsf.gov/statistics/seind/. Last accessed 6 February 2022.

Pauly, D. & Stergiou, K.I. (2005). Equivalence of results from two citation analyses: Thomson ISI’s Citation Index and Google’s Scholar service. *undefined*, 5, 33–35.

R Development Core Team. (2022). R: A language and environment for statistical computing. *R Foundation for Statistical Computing*.

Rawat, S. & Meena, S. (2014). Publish or perish: Where are we heading? *Journal of Research in Medical Sciences : The Official Journal of Isfahan University of Medical Sciences*, 19, 87.

Ryan Haley, M. (2012). Rank variability of the Publish or Perish metrics for economics and finance journals. *http://dx.doi.org/10.1080/13504851.2012.697115*, 20, 830–836.

Schillebeeckx, M., Maricque, B. & Lewis, C. (2013). The missing piece to changing the university culture. *Nature Biotechnology 2013 31:10*, 31, 938–941.

Shin, J.C. & Kehm, B.M. (2013). Institutionalization of world-class university in global competition. *Institutionalization of World-Class University in Global Competition*, 1–301.

Swihart, R.K., Sundaram, M., Höök, T.O. & Dewoody, J.A. (2016). Factors affecting scholarly performance by wildlife and fisheries faculty. *The Journal of Wildlife Management*, 80, 563–572.

Symonds, M.R.E., Gemmell, N.J., Braisher, T.L., Gorringe, K.L. & Elgar, M.A. (2006). Gender Differences in Publication Output: Towards an Unbiased Metric of Research Performance. *PLOS ONE*, 1, e127.

van Dijk, D., Manor, O. & Carey, L.B. (2014). Publication metrics and success on the academic job market. *Current biology : CB*, 24.

Warren, J.R. (2019). How much do you have to publish to get a job in a top sociology department? Or to get tenure? Trends over a generation. *Sociological Science*, 6, 172–196.

West, J. D., Jacquet, J., King, M. M., Correll, S. J. & Bergstrom, C. T. (2013). The role of gender in scholarly authorship. *PloS one*, 8, e66212.

Witteman, H.O., Hendricks, M., Straus, S. & Tannenbaum, C. (2019). Are gender gaps due to evaluations of the applicant or the science? A natural experiment at a national funding agency. *The Lancet*, 393, 531–540.

Xue, Y. & Larson, R.C. (2015). STEM crisis or STEM surplus? Yes and yes. *Monthly labor review*, 2015.

**Tables and Figures**

Table 1. Results of the GLMMs/LMMs (type II sum of squares) for academic performance before recruitment/promotion, career duration before recruitment/promotion, and difference in performance before and after recruitment /promotion. *n* represents the sample size in each model. The upper and lower 95% confidence limit (CL) of each regression coefficient (*β*) was derived from 1000 bootstrap samples

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | *n* | Response | Predictor | *β* | SE | Lower  95% CL | Upper 95% CL | *χ²* | *d.f.* | *P* |
| Model 1.  Academic performance (recruitment) | 134 | “Before” h-index (recruitment) | Year of recruitment | 0.0429 | 0.0004 | 0.0302 | 0.0494 | 4658.02 | 1 | < 0.001 |
|  |  |  | PhD university origin (Taiwan) | -0.0606 | 0.1097 | -0.1862 | 0.1527 | 0.03 | 1 | 0.855 |
|  |  |  | PhD university ranking | 0.0001 | 0.0002 | -0.0003 | 0.0003 | 0.13 | 1 | 0.722 |
|  |  |  | Gender (Male) | 0.4510 | 0.1326 | 0.2107 | 0.6590 | 15.52 | 1 | < 0.001 |
| Model 2.  Academic performance (promotion) | 58 | “Before” h-index  (promotion) | Year of promotion | 0.0048 | 0.0007 | -0.0086 | 0.0184 | 47.33 | 1 | < 0.001 |
|  |  |  | PhD university origin (Taiwan) | -0.1594 | 0.1138 | -0.3788 | 0.0504 | 1.96 | 1 | 0.161 |
|  |  |  | PhD university ranking | 0.0001 | 0.0002 | -0.0004 | 0.0003 | 0.00 | 1 | 0.979 |
|  |  |  | Gender (Male) | -0.0584 | 0.1365 | -0.2724 | 0.1815 | 0.18 | 1 | 0.669 |
| Model 3.  Career duration  (recruitment) | 133 | Duration before recruitment | “Before” h-index (recruitment) | 0.0193 | 0.0134 | -0.0085 | 0.0428 | 2.08 | 1 | 0.149 |
|  |  |  | Year of recruitment | 0.0377 | 0.0064 | 0.0265 | 0.0504 | 35.00 | 1 | < 0.001 |
|  |  |  | PhD university origin (Taiwan) | 0.1759 | 0.1009 | -0.0200 | 0.3671 | 3.04 | 1 | 0.081 |
|  |  |  | PhD university ranking | -0.0003 | 0.0002 | -0.0006 | 0.0001 | 2.21 | 1 | 0.137 |
|  |  |  | Gender (Male) | -0.0744 | 0.1198 | -0.2985 | 0.1820 | 0.39 | 1 | 0.535 |
| Model 4.  Career duration  (promotion) | 55 | Duration before  promotion | “Before” h-index (promotion) | -0.0105 | 0.0109 | -0.0316 | 0.0107 | 0.92 | 1 | 0.338 |
|  |  |  | Year of promotion | 0.0145 | 0.0064 | 0.0026 | 0.0281 | 5.08 | 1 | 0.024 |
|  |  |  | PhD university origin (Taiwan) | 0.1248 | 0.0945 | -0.0802 | 0.3004 | 1.74 | 1 | 0.187 |
|  |  |  | PhD university ranking | -0.0002 | 0.0001 | -0.0004 | 0.0001 | 1.29 | 1 | 0.256 |
|  |  |  | Gender (Male) | -0.1617 | 0.1064 | -0.3655 | 0.0416 | 2.31 | 1 | 0.129 |
| Model 5.  Difference in performance (recruitment) | 100 | “After” h-index － “Before” h-index (recruitment) | Year of recruitment | -0.1866 | 0.0476 | -0.2811 | -0.0974 | 15.38 | 1 | < 0.001 |
|  |  |  | PhD university origin (Taiwan) | -0.5712 | 0.8809 | -2.2694 | 1.2721 | 0.42 | 1 | 0.517 |
|  |  |  | PhD university ranking | 0.0009 | 0.0015 | -0.0020 | 0.0038 | 0.38 | 1 | 0.537 |
|  |  |  | Gender (Male) | 0.2487 | 0.9837 | -1.7603 | 2.2468 | 0.06 | 1 | 0.800 |
| Model 6.  Difference in performance (promotion) | 46 | “After” h-index － “Before” h-index (promotion) | Year of promotion | -0.1671 | 0.0972 | -0.3745 | 0.0291 | 2.96 | 1 | 0.086 |
|  |  |  | PhD university origin (Taiwan) | -2.1577 | 1.1561 | -4.4676 | -0.0270 | 3.48 | 1 | 0.062 |
|  |  |  | PhD university ranking | 0.0013 | 0.0018 | -0.0024 | 0.0052 | 0.51 | 1 | 0.474 |
|  |  |  | Gender (Male) | 1.1835 | 1.3168 | -1.3557 | 3.9062 | 0.81 | 1 | 0.369 |

Figure 1. Distribution of the universities from which the 145 PIs obtained their PhD degrees. Percentages of PhD degrees obtained from the USA, Taiwan, and the UK are as noted; “Other” includes all the other countries with percentages less than 4.0%.

Figure 2. Distribution of the ranking of universities from which PIs obtained their PhD degrees. Dashed lines indicate the medians of university ranking for PIs with foreign degrees (median ranking = 108 out of 97 PIs) and Taiwanese degrees (median ranking = 252 out of 48 PIs).

Figure 3. Temporal variations in academic performance and career duration before recruitment and promotion. Each point represents an individual PI; solid lines represent significant relationships (*P* values are derived from the GLMMs); shaded areas indicate 95% confidence intervals. Note that female and male PIs are shown in separate lines in panel (a) (GLMM gender: *P* < 0.001).

Figure 4. Difference in academic performance before and after recruitment/promotion (“After” h-index minus “Before” h-index) in relation to year of recruitment/promotion and PhD university origin. Each point represents an individual PI; solid/dashed line represents significant/non-significant relationship (*P* values are derived from the LMMs); shaded area indicate 95% confidence intervals.

Figure 1.

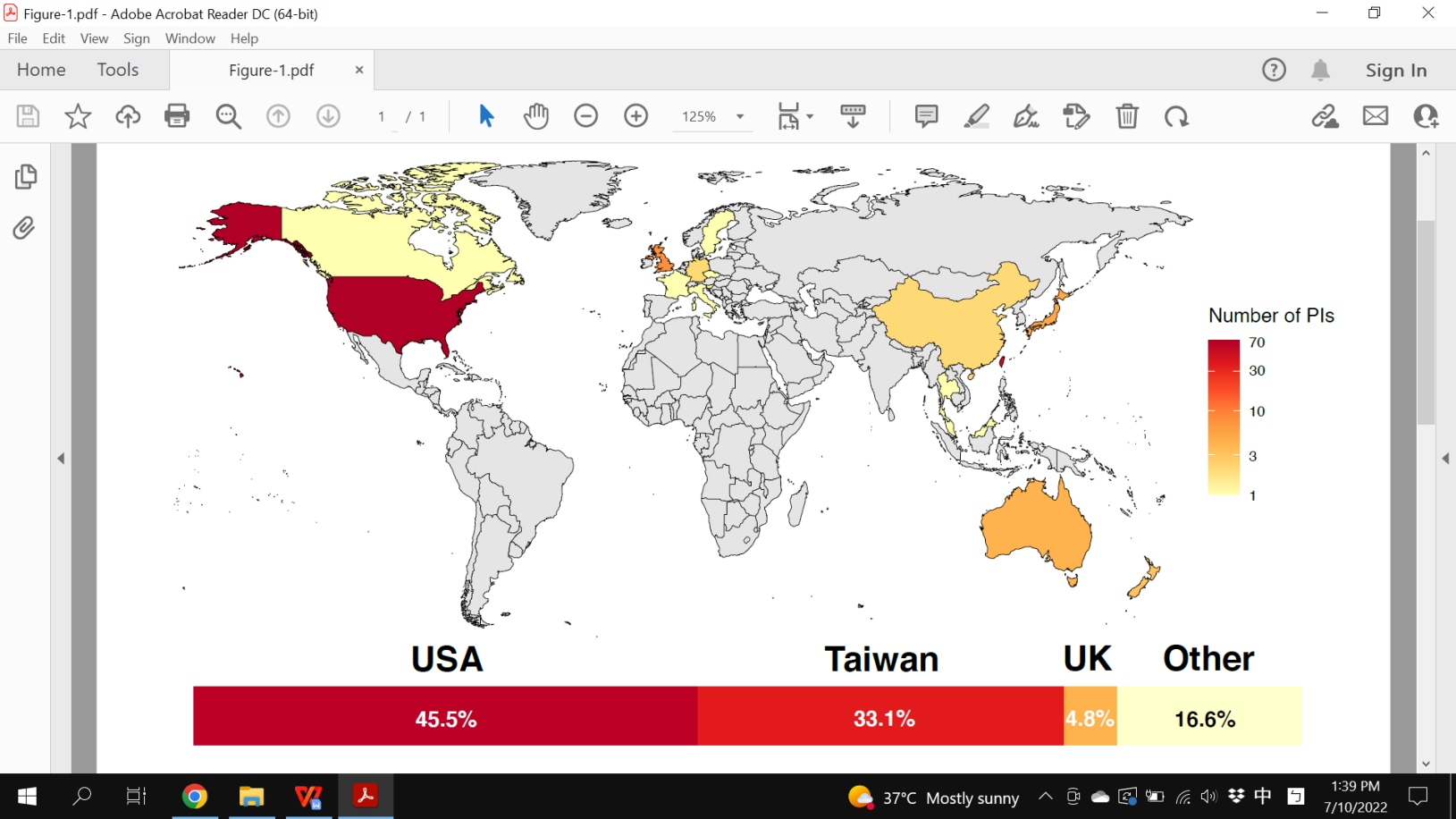


Figure 2.



Figure 3.

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Figure 4.

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