Increased academic performance and prolonged career duration among Taiwanese academic faculty in ecology and evolutionary biology

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Abstract:

Academic job markets have become increasingly challenging worldwide, yet it remains poorly characterized how competitively-successful candidates should be and what the underlying determinants of their success are. Focusing on ecology and evolutionary biology, we analyzed the academic performance (measured as h-index) as well as the duration for landing a faculty position and promotion to full professor of 145 principal investigators (PI) over the past 34 years in Taiwan. We found that faculty members had higher performance and longer duration before recruitment as a new PI in recent years. Performance before promotion remained stable, whereas the duration increased over time. The origin and prestige of PhD university had no effect on the performance or duration neither for recruitment nor promotion. Our findings highlight the increasingly crucial role of academic performance, rather than PhD degree itself, in determining academic success.

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 constant in the past four decades (Schillebeeckx et al. 2013, Larson et al. 2014). For example, in the US, only 7.6% new PhDs in life sciences landed tenure-track positions within three years after graduation in 2010; this surplus of PhD supply has widely expanded to other STEM fields (NSF 2018).

The intensifying competition for tenure-track positions, due to disproportionately high numbers of accumulating applicants per position (Larson et al. 2014), has resulted in higher expectations for academic performance shaped by a “publish or perish” (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). 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 STEM PhDs work as postdoctoral researchers for a prolonged period and wait for future opportunities until they are competitive enough in the academic job market (Swihart et al. 2016), whereas some turn to alternative careers outside academia. From the CNRS example, Brischoux and Angelier (2015) also showed that the time elapsed between first publication and recruitment had increased from 3.25 to 8 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, during which the postdocs have to trade off families for research, with fixed-term and relatively low-paying jobs (Acton et al. 2019).

Despite widely claimed that publication expectations and career duration have surged, empirical quantification of the determinants regarding the evolution of academic profiles over time remains understudied. In addition to research productivity, which directly predicts the success of recruitment (van Dijk et al. 2014),

the origin and prestige of doctoral-granting institutes have become critical indicators for academic employment (van Dijk et al. 2014), especially in East Asian countries (Shin and Kehm 2013). With the initiative to build world-class universities, many East Asian universities preferentially recruit returnees who obtained PhD degrees from top-ranking universities in Western countries. Hence, competition for limited tenure-track positions is exacerbated when foreign PhDs are favored, leaving domestically-trained PhDs substantially deprived of career development opportunities (Chen 2021). Yet, whether and to what extent publication expectations and career duration differ between domestic and foreign PhDs, and if their academic productivity varies between pre- and post-employment, remain largely unexplored.

In this study, we examined how academic performance as well as the duration for landing tenure-track positions and promotion to full professor changed over time, and their links to PhD university origin, PhD university ranking, and gender. Specifically, we tested the following questions: (1) Is the academic performance for recruitment as a new principal investigator (PI) or promotion to full professor affected by the year of recruitment, PhD university origin, ranking, and gender? (2) Is the duration for recruitment or promotion affected by the year of recruitment, academic performance, PhD university origin, ranking, and gender? (3) Does the academic performance of PIs differ before and after recruitment or promotion? To address these questions, we studied the trend between 1987 and 2021 on 145 faculty members in the field of ecology and evolutionary biology in Taiwan. We aim to provide empirical evidence to illustrate the temporal variations in researchers' publication performance necessary to secure a faculty position and get a promotion, the role of PhD university origin and

prestige as well as gender in determining the success of academic employment, and how these factors contribute to PIs' future academic performance.

Materials and Methods:

(a) 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. Together, these eight institutes encompassed 34 academic departments/divisions that serve as tenure homes to the field of ecology and evolutionary biology (e.g., ecology, evolution, biodiversity; see Appendix A for details). We excluded researchers in biomedical sciences because publication rates, performance, and collaboration opportunities can vary considerably among these fields (Laurance et al. 2013). A total of 145 PIs who had an updated curriculum vitae online (e.g., institutional/personal websites or Open Researcher and Contributor ID [ORCID]) were identified in our survey, with key information on the university and year of PhD completion, the year of recruitment as a new PI, the year of promotion to full professor, and gender, which is well-documented as a key determinant of performance (Witteman et al. 2019). The university ranking was determined based on 2022 QS World University Rankings. The duration for recruitment as a new PI was the time between PhD completion and landing a position; the duration for

promotion to full professor was the time between landing a position and getting a promotion.

(b) Measurement of academic performance

We collected data on academic performance, measured as h-index (Hirsch 2005), from the Publish or Perish software using Google Scholar data, which is freely available and more transparent for tenure reviews (Pauly and Stergiou 2005). We included peer-reviewed papers and book chapters regardless of authorship for calculation of h-index, while PhD theses and conference presentations were excluded. Although other matrices, such as the number of publications and citations, are also commonly used for measuring academic performance, they were both highly correlated with h-index in our study (publications: $r = .906$, $p < .001$; citations: $r = .768$, $p < .001$), as had also been found in previous studies (Ryan Haley 2012, Laurance et al. 2013). We thus focused on h-index, a widely accepted measure of academic success that incorporates the assessment of quantity (number of papers) and quality (citations) of publications (Glänzel 2006).

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. We used the duration of five years because it 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” getting a job and promotion to full professor because these publications, either as published papers or

142 manuscripts “accepted” or “in press”, would most likely contribute to the evaluation of
143 academic performance prior to successful recruitment and promotion. For example,
144 a new PI who started the position in 2010 would have an h-index measured for
145 publications between 2006 and 2010 (i.e., “before” h-index), and another h-index
146 measured for publications between 2011 and 2015 (i.e., “after” h-index). We did not
147 consider “after” h-indexes for PIs who were recruited as a new PI or promoted to full
148 professor less than five years so that all performances had the same duration to
149 compare with.
150
151 (c) Statistical analysis
152 *Academic performance before recruitment/promotion.* To examine how various
153 factors affect the academic performance before recruitment as a new PI and
154 promotion to full professor, we fit generalized linear mixed-effects models (GLMMs)
155 with PhD university origin (binary variable: Taiwan vs. Foreign), PhD university
156 ranking, year of recruitment/promotion, gender, and interactions with year as fixed
157 effects, the department nested within university as random effects, and the h-index
158 before recruitment/promotion as the response.
159
160 *Duration for recruitment/promotion.* To examine how various factors affect the
161 duration for recruitment and promotion, we fit GLMMs with PhD university origin,
162 PhD university ranking, year of recruitment/promotion, gender, the h-index before
163 recruitment/promotion, and interactions with year as fixed effects, the department
164 nested within university as random effects, and the duration for
165 recruitment/promotion as the response.

Changes in academic performance before and after recruitment/promotion. To compare the academic performance before and after recruitment and promotion, we fit GLMMs with PhD university origin, PhD university ranking, year of recruitment/promotion, gender, and interactions with year as fixed effects, the department nested within university as random effects, and the difference in h-index before and after recruitment/promotion (i.e., “after” h-index – “before” h-index) as the response.

GLMMs were performed using the package “lme4” (Bates et al. 2015); post-hoc pairwise comparisons were performed using the package “emmeans” (Lenth 2021). Response variables (h-index and duration for recruitment/promotion) were log-transformed prior to analyses to meet the assumption of normality. The assumption of independence and equal variance were both assessed using the residual plots. Non-significant interactions ($p > .05$) were dropped from our final model results. All analyses were performed in R version 4.1.2 (R Development Core Team 2014).

Results:

In total, we collected data on145 tenure-track faculty members, of which 44.8% were full professors, 24.8% were associate professors, and 30.3% were assistant professors. The gender difference was substantial, with males (112) around four times as prevalent as females (33). The universities from which the PIs obtained their PhD degrees varied widely in the ranking of prestige among 73 universities

190 from 16 countries (figure S1, figure S2). Nearly half of the PIs obtained their degrees
191 from the USA (45.5%), followed by Taiwan (33.1%), and relatively few from the UK
192 (4.8%) and other countries.
193
194 Faculty members who landed tenure-track positions more recently had higher
195 academic performance (h-index) before recruitment, whereas PIs performed equally
196 well before promotion to full professor irrespective of time (table 1, figure 1a–1b).
197 Although males had on average higher performance than females before
198 recruitment, no such gender difference was found before promotion. PhD university
199 origin and ranking had no effect on the performance either before recruitment or
200 before promotion (table 1).
201
202 Faculty members who landed positions more recently spent more time post-PhD
203 before recruitment, but higher academic performance reduced this duration (table 1,
204 figure 1c). On the other hand, PIs also spent more time before promotion to full
205 professor in recent years, yet the duration was not affected by the academic
206 performance (table 1, figure 1d). PhD university origin, ranking, and gender had no
207 effect on the duration for either recruitment or promotion (table 1).
208
209 The difference in academic performance before and after recruitment ("after" h-index
210 – "before" h-index) decreased for PIs who landed positions more recently, while PhD
211 university origin, ranking, and gender had no effect on the performance difference
212 (table 1, figure 2a–2b). In contrast, the performance difference before and after
213 promotion to full professor was not affected by the year of promotion, PhD university

214 ranking, or gender, yet the difference tended to be higher for PIs with foreign
215 degrees compared to those with Taiwanese degrees (table 1, figure 2c–2d).
216
217 **Discussion:**
218 Overall, we showed that the academic performance of PIs before landing faculty
219 positions increased over years, whereas the performance before promotion to full
220 professor remained relatively unchanged. We also found that the duration for both
221 recruitment and promotion increased in recent years. These results provide empirical
222 evidence supporting the suspicion that publication requirements and expectations
223 have risen over time in ecology and evolution in Taiwan, in line with many academic
224 job markets worldwide (Rawat and Meena 2014, Warren 2019; figure 3).
225
226 The increase in academic performance of PIs before recruitment suggests that the
227 academic job market has become increasingly competitive over time, which is likely
228 driven by a relatively lower demand for tenure-track professors compared to the
229 supply of new PhDs (Larson et al. 2014). Consequently, the duration post-PhD
230 would be prolonged if the applicants are not competitive enough. However, higher
231 academic performance could help shorten the time to land a position. Therefore,
232 early-career researchers should focus on their publications to demonstrate the
233 competence for academic success. On the other hand, the academic performance of
234 PIs before promotion remained similar over years, suggesting that the requirements
235 for promotion might not have changed much over time. Interestingly, the time to full
236 professor has lengthened in recent years but was not affected by academic
237 performance, possibly due to increasing consideration of accomplishments such as

238 teaching and administrative services by employment institutes in addition to research
239 outputs. The different patterns in academic performance and career duration
240 between recruitment and promotion phase are likely because applicants face
241 increasing competition with others during recruitment and higher performance would
242 be advantageous for securing a position, whereas getting a promotion depends
243 mainly on meeting the institutes' requirements rather than comparing with others'
244 performance.
245
246 We found that the average performance of a new male PI was higher than that of a
247 new female PI, indicating that the standards for evaluating the suitability of a
248 potential faculty member might be higher for males than females (Symonds et al.
249 2006). But after recruitment, the performance expectations for promotion to full
250 professor did not differ between male and female PIs. In contrast to a previous study
251 (van Dijk et al. 2014), we found no evidence of PhD university origin and ranking
252 influencing the career duration for either recruitment or promotion. Instead, academic
253 performance during PhD and/or post-PhD period is more important in determining
254 the academic success compared with the prestige of education itself.
255
256 The difference in performance before and after recruitment decreased over years.
257 Earlier PIs had on average higher h-indexes after recruitment compared with before
258 recruitment, yet such a "performance boost" has declined in recent years. This could
259 be due to increasing teaching and administrative demands of new PIs, reducing the
260 time available for research. Strikingly, we found that PIs performed consistently
261 before and after recruitment regardless of PhD university origin or ranking. However,

PIs with PhD degrees in Taiwan showed a decrease in performance after promotion to full professor, whereas those with foreign PhD degrees had relatively consistent performance. One 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, helps maintain their performance.

Our findings were based mainly on PIs in ecology and evolutionary biology. Since the nature of academic job markets can vary considerably among different fields of biology (Larson et al. 2014), the results should be interpreted carefully when applied to the fields outside the scope of this study. Nonetheless, our findings confirm that succeeding in academia has become more challenging, with publication requirements and career duration both increasing over time. In the face of increasingly competitive academic job markets, boosting performance is the key to career success in academia.

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.

Competing interests:

The authors declare no competing interests.

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347
348

349 **Figure captions:**
350

351 Figure 1. Temporal variations in academic performance (*a & b*) and career duration
352 (*c & d*) for recruitment and promotion. Each point represents an individual PI, with
353 points in (*c*) colored by h-index. Solid/dashed lines represent significant/non-
354 significant relationships predicted from GLMMs; shaded areas indicate 95%
355 confidence intervals.
356

357 Figure 2. Difference in academic performance before and after ("after" h-index –
358 "before" h-index) recruitment as a new PI (*a & b*) and promotion to full professor (*c &*
359 *d*) in relation to year of recruitment/promotion and PhD university origin. Each point
360 represents an individual PI. Solid/dashed line represents significant/non-significant
361 relationship predicted from GLMMs; shaded areas indicate 95% confidence intervals.
362

363 Figure 3. A challenging pathway toward academic success. Many PhD students
364 struggle and are often left to sink or swim. After successfully landing as postdocs,
365 they then face a steep, overhang "cliff" to climb over before becoming faculty
366 members, who still need to overcome gaps and obstacles on the way to full
367 professors.
368

Table 1. Results of the GLMMs (type III sum of squares) for analyzing academic performance, career duration, and difference in performance before and after recruitment as a new PI and promotion to full professor.

Response	Predictor	χ^2	d.f.	*p*
Academic performance (new PI)	PhD university origin	1.42	1	.234
	PhD university ranking	0.45	1	.503
	Year of recruitment	74.68	1	**< .001**
	Gender	5.73	1	**.017**
Academic performance (promotion)	PhD university origin	0.06	1	.812
	PhD university ranking	1.06	1	.304
	Year of promotion	0.97	1	.324
	Gender	0.07	1	.791
Duration (new PI)	Academic performance	6.10	1	**.014**
	PhD university origin	1.01	1	.315
	PhD university ranking	1.82	1	.178
	Year of recruitment	43.08	1	**< .001**
	Gender	0.78	1	.377
	Academic performance x Year of recruitment	6.06	1	**.014**
Duration (promotion)	Academic performance	1.87	1	.171
	PhD university origin	1.96	1	.161
	PhD university ranking	0.62	1	.430
	Year of promotion	7.03	1	**.008**
	Gender	3.18	1	.075
Difference in performance (new PI)	PhD university origin	0.42	1	.517
	PhD university ranking	0.38	1	.537
	Year of recruitment	15.40	1	**< .001**
	Gender	0.06	1	.800
Difference in performance (promotion)	PhD university origin	3.48	1	.062
	PhD university ranking	0.51	1	.474
	Year of promotion	2.96	1	.086
	Gender	0.81	1	.369

p values < .05 are highlighted in bold

373 **Supplementary information:**

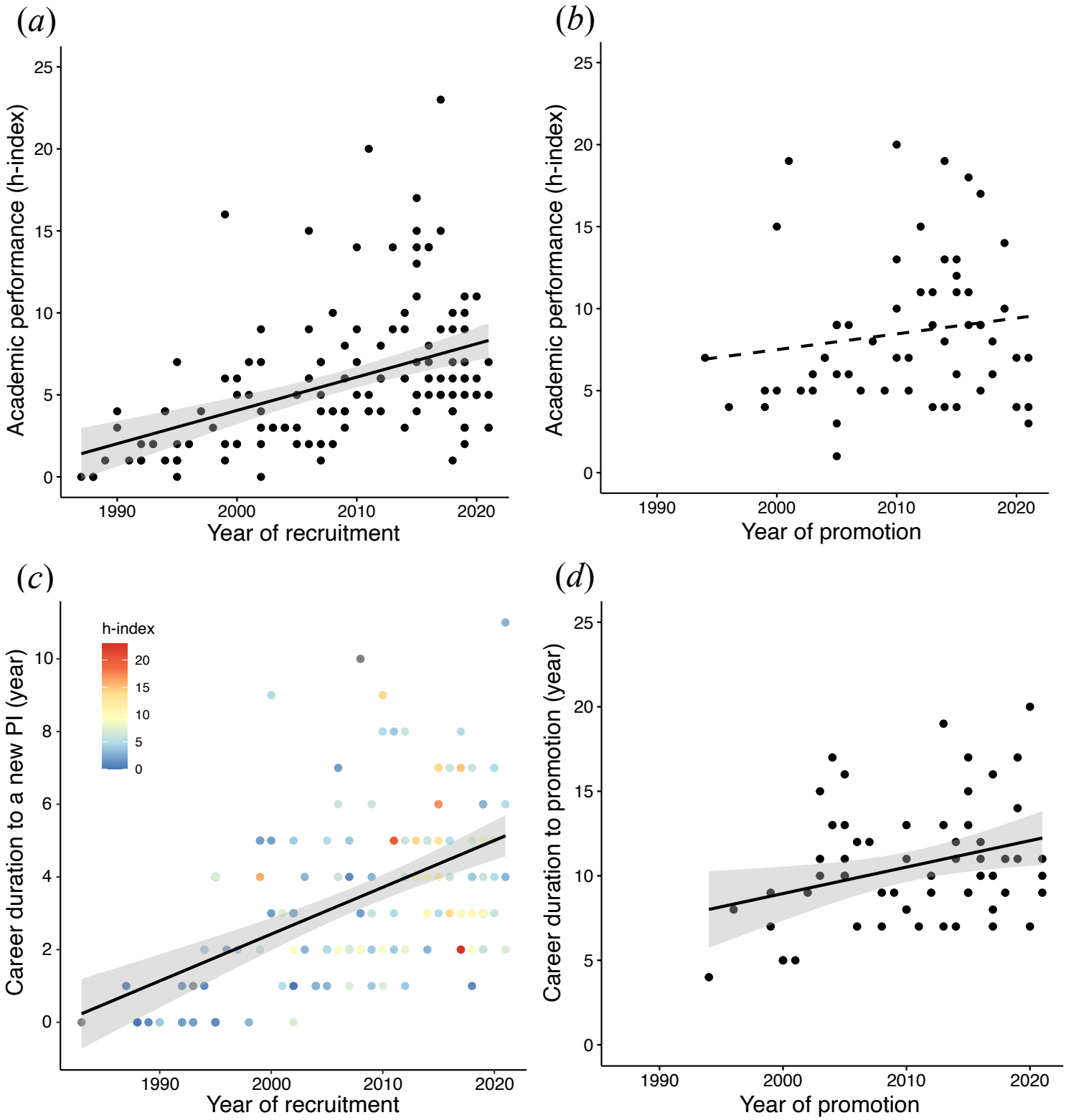
374 Figure S1. Distribution of the universities from which the 145 PIs obtained their PhD
375 degrees. Percentages of PhD degrees obtained from the USA, Taiwan, and the UK
376 are as noted, whereas “other” includes those less than 4%.

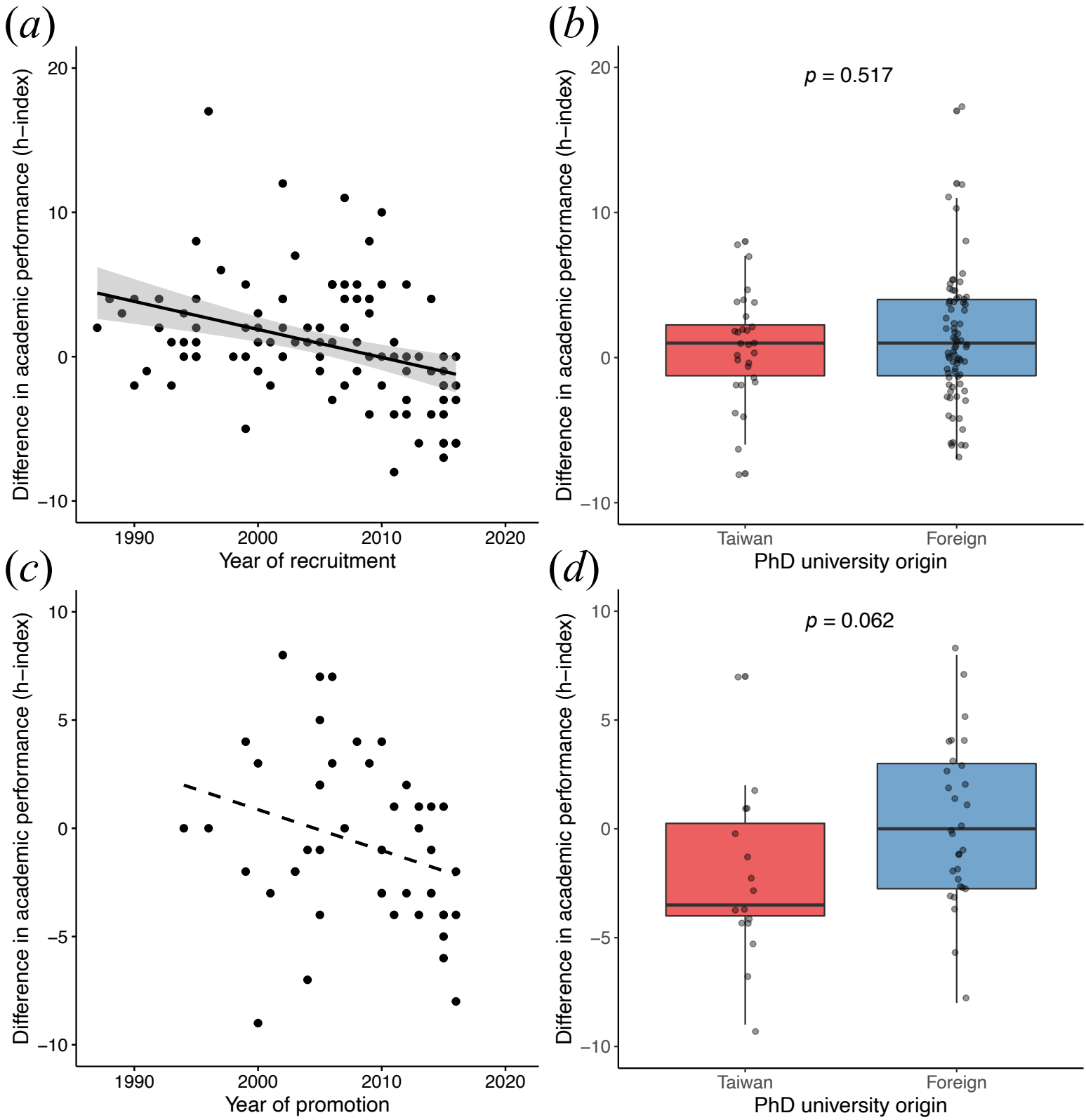
377

378 Figure S2. Distribution of the ranking of universities from which PIs obtained their
379 PhD degrees. Dashed lines indicate medians of university ranking for Taiwanese
380 (252) and foreign (108) PhD degrees.

381

382


(a)
Academic performance (h-index)
Year of recruitment
(b)
Academic performance (h-index)
Year of promotion
(c)
h-index
Career duration to a new PI (year)
Year of recruitment
(d)
Career duration to promotion (year)
Year of promotion


(a)
Difference in academic performance (h−index)
20
10
0
−10
1990
2000
2010
2020
Year of recruitment
(b)
p = 0.517
Difference in academic performance (h−index)
20
10
0
−10
Taiwan
Foreign
PhD university origin
(c)
Difference in academic performance (h−index)
10
5
0
−5
−10
1990
2000
2010
2020
Year of promotion
(d)
p = 0.062
Difference in academic performance (h−index)
10
5
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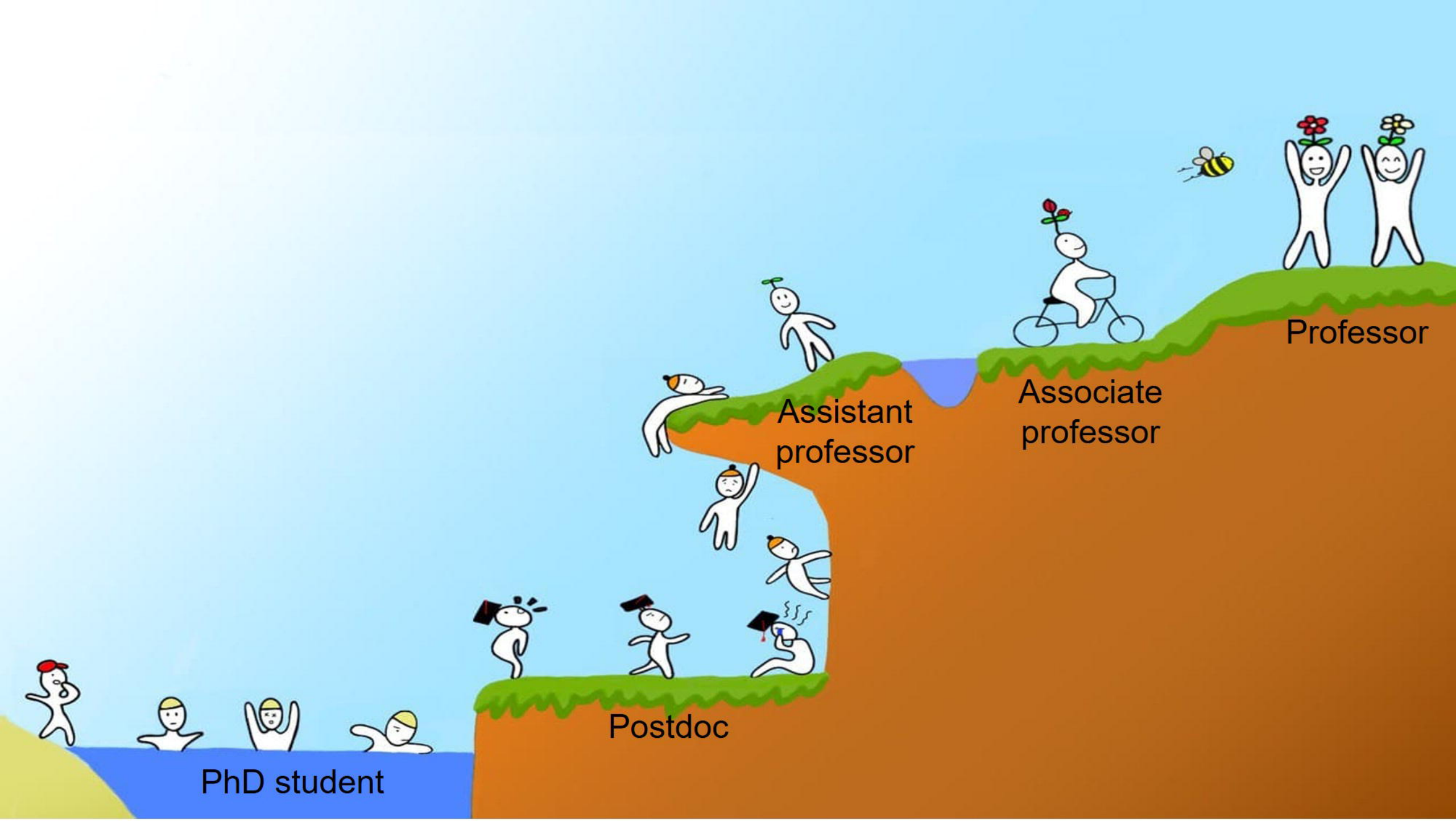
Taiwan
Foreign
PhD university origin


PhD student
Postdoc
Assistant professor
Associate professor
Professor