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2 **Increased academic performance and prolonged career duration**  
3 **among Taiwanese academic faculty in ecology and evolutionary**  
4 **biology**

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6 Gen-Chang Hsu<sup>1</sup>, Wei-Jiun Lin<sup>2</sup>, Syuan-Jyun Sun<sup>3,4\*</sup>

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8 <sup>1</sup>Department of Life Science, National Taiwan University, Taipei, Taiwan

9 <sup>2</sup>Institute of Ecology and Evolutionary Biology, National Taiwan University, Taipei,

10 Taiwan

11 <sup>3</sup>Department of Ecology & Evolutionary Biology, University of Michigan, Ann Arbor,

12 MI 48109, USA

13 <sup>4</sup>International Degree Program in Climate Change and Sustainable Development,

14 National Taiwan University, Taipei 10617, Taiwan

15

16

17

18 \*Corresponding author:

19 [sysun@umich.edu](mailto:sysun@umich.edu)

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21 Keywords: academic performance, career duration, faculty, academic job market,

22 publication

23 **Abstract:**

24 Academic job markets have become increasingly challenging worldwide, yet it  
25 remains poorly characterized how competitively-successful candidates should be  
26 and what the underlying determinants of their success are. Focusing on ecology and  
27 evolutionary biology, we analyzed the academic performance (measured as h-index)  
28 as well as the duration for landing a faculty position and promotion to full professor of  
29 145 principal investigators (PI) over the past 34 years in Taiwan. We found that  
30 faculty members had higher performance and longer duration before recruitment as  
31 a new PI in recent years. Performance before promotion remained stable, whereas  
32 the duration increased over time. The origin and prestige of PhD university had no  
33 effect on the performance or duration neither for recruitment nor promotion. Our  
34 findings highlight the increasingly crucial role of academic performance, rather than  
35 PhD degree itself, in determining academic success.

36

37 **Introduction:**

38 The academic job market has been increasingly competitive in many fields of  
39 science, technology, engineering, and mathematics (STEM) (Cyranoski et al. 2011,  
40 Ghaffarzadegan et al. 2015, Xue and Larson 2015), with more PhDs produced but  
41 vacancies for tenure-track academic positions remaining constant in the past four  
42 decades (Schillebeeckx et al. 2013, Larson et al. 2014). For example, in the US, only  
43 7.6% new PhDs in life sciences landed tenure-track positions within three years after  
44 graduation in 2010; this surplus of PhD supply has widely expanded to other STEM  
45 fields (NSF 2018).

46

47 The intensifying competition for tenure-track positions, due to disproportionately high  
48 numbers of accumulating applicants per position (Larson et al. 2014), has resulted in  
49 higher expectations for academic performance shaped by a “publish or perish”  
50 (Garfield 1996). A survey of evolutionary biologists recruited as junior researchers at  
51 the National Centre for Scientific Research (CNRS) in France showed that  
52 academics recruited in 2013 published nearly twice as many papers as those  
53 recruited in 2005 did (Brischoux and Angelier 2015). Although the minimum  
54 education requirement for a tenure-track position is having a PhD degree, it has  
55 become increasingly frequent for applicants to have one or even more postdoctoral  
56 appointments. Consequently, many STEM PhDs work as postdoctoral researchers  
57 for a prolonged period and wait for future opportunities until they are competitive  
58 enough in the academic job market (Swihart et al. 2016), whereas some turn to  
59 alternative careers outside academia. From the CNRS example, Brischoux and  
60 Angelier (2015) also showed that the time elapsed between first publication and  
61 recruitment had increased from 3.25 to 8 years. The increase in postdoctoral training  
62 time can be detrimental to not only the scientific community but also individuals  
63 because this increases the age at which researchers become independent, during  
64 which the postdocs have to trade off families for research, with fixed-term and  
65 relatively low-paying jobs (Acton et al. 2019).

66

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

71 the origin and prestige of doctoral-granting institutes have become critical indicators  
72 for academic employment (van Dijk et al. 2014), especially in East Asian countries  
73 (Shin and Kehm 2013). With the initiative to build world-class universities, many East  
74 Asian universities preferentially recruit returnees who obtained PhD degrees from  
75 top-ranking universities in Western countries. Hence, competition for limited tenure-  
76 track positions is exacerbated when foreign PhDs are favored, leaving domestically-  
77 trained PhDs substantially deprived of career development opportunities (Chen  
78 2021). Yet, whether and to what extent publication expectations and career duration  
79 differ between domestic and foreign PhDs, and if their academic productivity varies  
80 between pre- and post-employment, remain largely unexplored.

81

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

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

97

## 98 **Materials and Methods:**

### 99 (a) Data collection

100 Between November and December, 2021, we surveyed tenure-track faculty  
101 members at seven universities in Taiwan, all of which were qualified as research-  
102 intensive universities and ranked top 150 in Asia according to 2022 QS Asia  
103 University Rankings (<https://www.topuniversities.com/>). We also surveyed  
104 academics from Academia Sinica, a leading academic institution in Taiwan.  
105 Together, these eight institutes encompassed 34 academic departments/divisions  
106 that serve as tenure homes to the field of ecology and evolutionary biology (e.g.,  
107 ecology, evolution, biodiversity; see Appendix A for details). We excluded  
108 researchers in biomedical sciences because publication rates, performance, and  
109 collaboration opportunities can vary considerably among these fields (Laurance et al.  
110 2013). A total of 145 PIs who had an updated curriculum vitae online (e.g.,  
111 institutional/personal websites or Open Researcher and Contributor ID [ORCID])  
112 were identified in our survey, with key information on the university and year of PhD  
113 completion, the year of recruitment as a new PI, the year of promotion to full  
114 professor, and gender, which is well-documented as a key determinant of  
115 performance (Witteaman et al. 2019). The university ranking was determined based  
116 on 2022 QS World University Rankings. The duration for recruitment as a new PI  
117 was the time between PhD completion and landing a position; the duration for

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

120

121 (b) Measurement of academic performance

122 We collected data on academic performance, measured as h-index (Hirsch 2005),

123 from the Publish or Perish software using Google Scholar data, which is freely

124 available and more transparent for tenure reviews (Pauly and Stergiou 2005). We

125 included peer-reviewed papers and book chapters regardless of authorship for

126 calculation of h-index, while PhD theses and conference presentations were

127 excluded. Although other matrices, such as the number of publications and citations,

128 are also commonly used for measuring academic performance, they were both

129 highly correlated with h-index in our study (publications:  $r = .906$ ,  $p < .001$ ; citations:  $r$

130  $= .768$ ,  $p < .001$ ), as had also been found in previous studies (Ryan Haley 2012,

131 Laurance et al. 2013). We thus focused on h-index, a widely accepted measure of

132 academic success that incorporates the assessment of quantity (number of papers)

133 and quality (citations) of publications (Glänzel 2006).

134

135 We calculated h-index within the five-year interval both before and after the year of

136 recruitment and promotion, generating up to four h-indexes for each PI. We used the

137 duration of five years because it is commonly used by institutes to evaluate the most

138 recent academic performance both for recruiting a new PI and for promotion to full

139 professor. The publications and citations during the year of recruitment and

140 promotion were considered as the performance “before” getting a job and promotion

141 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.

166

167 *Changes in academic performance before and after recruitment/promotion.* To

168 compare the academic performance before and after recruitment and promotion, we

169 fit GLMMs with PhD university origin, PhD university ranking, year of

170 recruitment/promotion, gender, and interactions with year as fixed effects, the

171 department nested within university as random effects, and the difference in h-index

172 before and after recruitment/promotion (i.e., “after” h-index – “before” h-index) as the

173 response.

174

175 GLMMs were performed using the package “lme4” (Bates et al. 2015); post-hoc

176 pairwise comparisons were performed using the package “emmeans” (Lenth 2021).

177 Response variables (h-index and duration for recruitment/promotion) were log-

178 transformed prior to analyses to meet the assumption of normality. The assumption

179 of independence and equal variance were both assessed using the residual plots.

180 Non-significant interactions ( $p > .05$ ) were dropped from our final model results. All

181 analyses were performed in R version 4.1.2 (R Development Core Team 2014).

182

183

#### 184 **Results:**

185 In total, we collected data on 145 tenure-track faculty members, of which 44.8% were

186 full professors, 24.8% were associate professors, and 30.3% were assistant

187 professors. The gender difference was substantial, with males (112) around four

188 times as prevalent as females (33). The universities from which the PIs obtained

189 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,

262 PIs with PhD degrees in Taiwan showed a decrease in performance after promotion  
263 to full professor, whereas those with foreign PhD degrees had relatively consistent  
264 performance. One possible explanation is that the training and experiences from  
265 foreign universities may have equipped those PIs with greater professional abilities,  
266 which together with international connections and collaboration opportunities, helps  
267 maintain their performance.

268

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

277

278 **Authors' contributions:**

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

282

283 **Competing interests:**

284 The authors declare no competing interests.

285

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288

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291

292

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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	$\chi^2$	d.f.	<i>p</i>
Academic performance (new PI)	PhD university origin	1.42	1	.234
	PhD university ranking	0.45	1	.503
	Year of recruitment	74.68	1	<b>&lt; .001</b>
	Gender	5.73	1	<b>.017</b>
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	<b>.014</b>
	PhD university origin	1.01	1	.315
	PhD university ranking	1.82	1	.178
	Year of recruitment	43.08	1	<b>&lt; .001</b>
	Gender	0.78	1	.377
	Academic performance x Year of recruitment	6.06	1	<b>.014</b>
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	<b>.008</b>
	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	<b>&lt; .001</b>
	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

369

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372

373 **Supplementary information:**

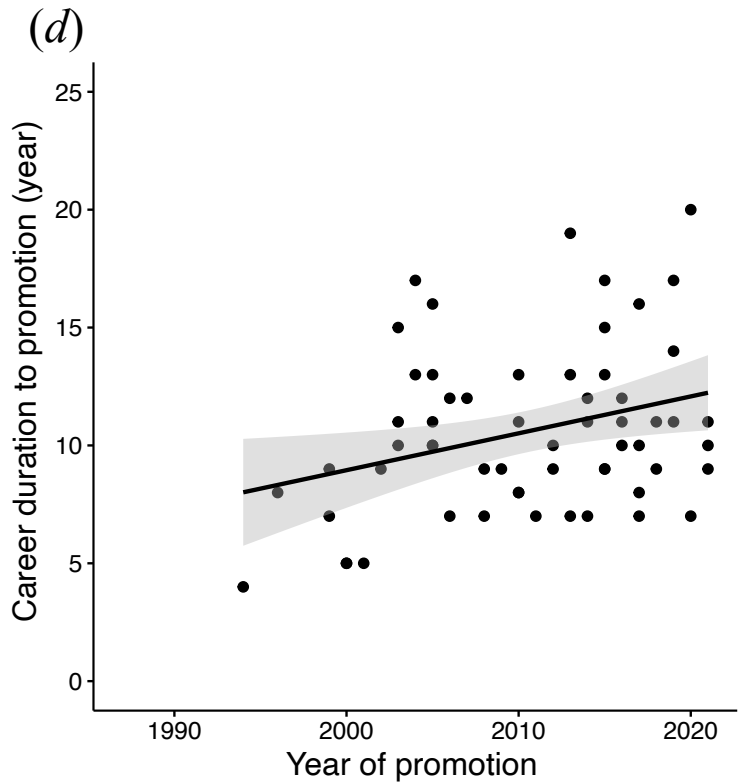
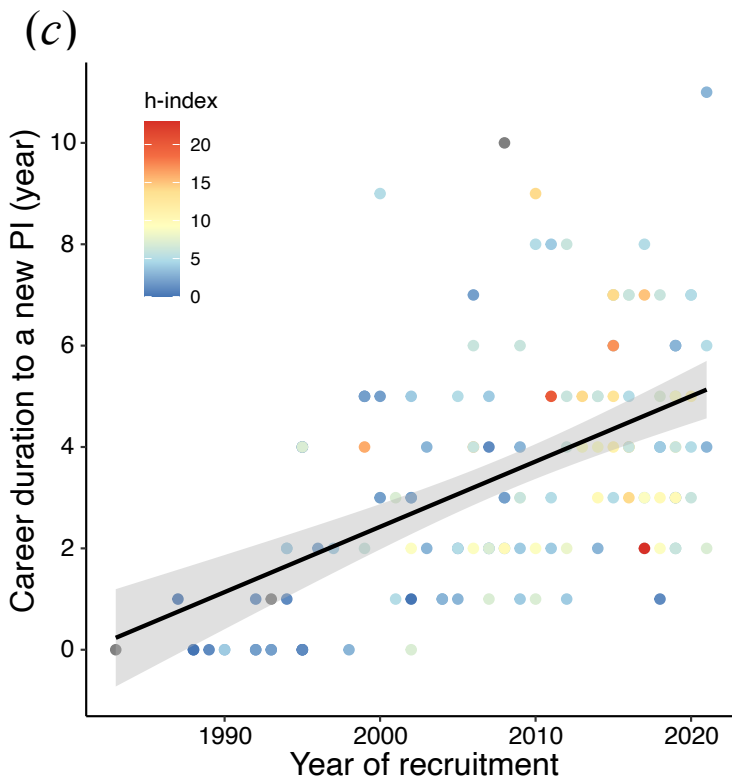
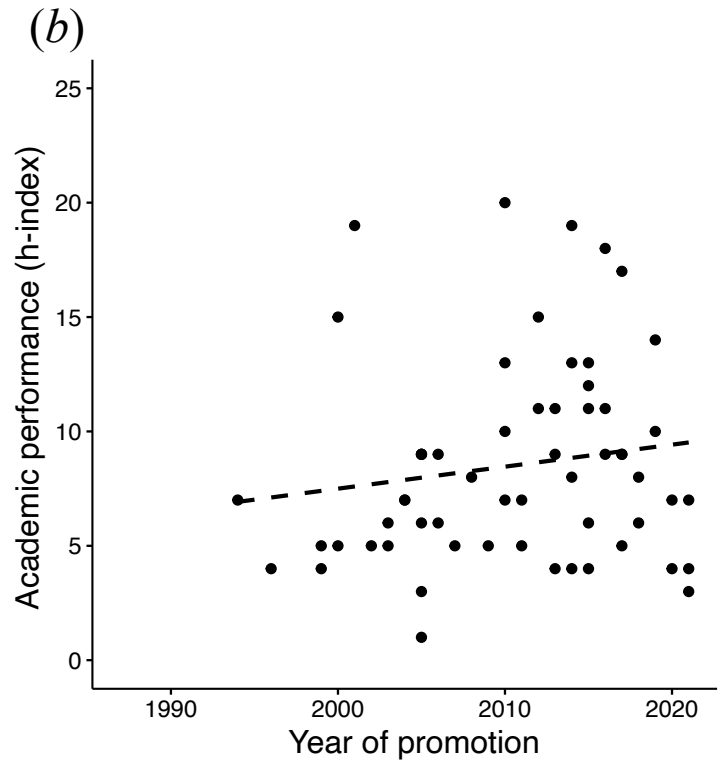
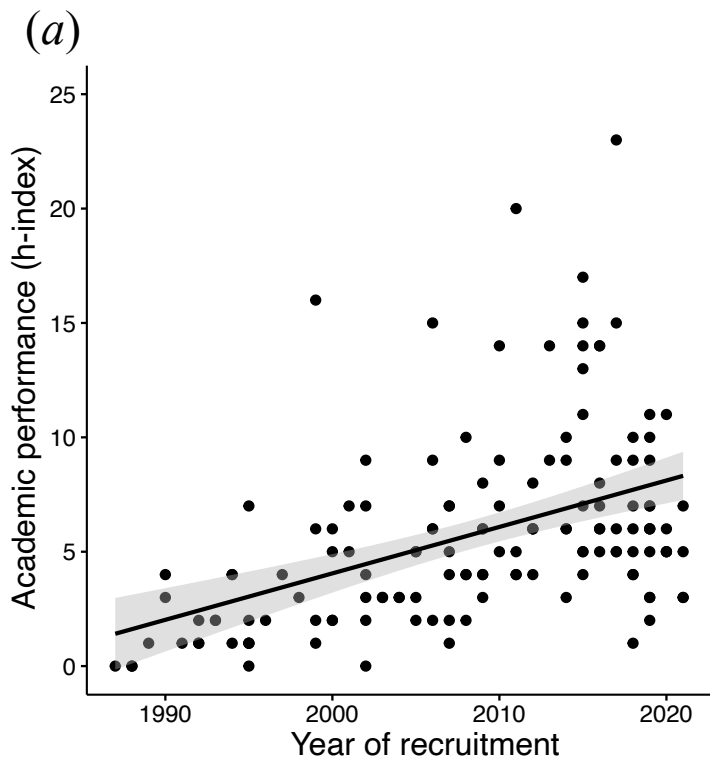
374 Figure S1. Distribution of the universities from which the 145 PIs obtained their PhD  
375 degrees. Percentages of PhD degrees obtained from the USA, Taiwan, and the UK  
376 are as noted, whereas “other” includes those less than 4%.

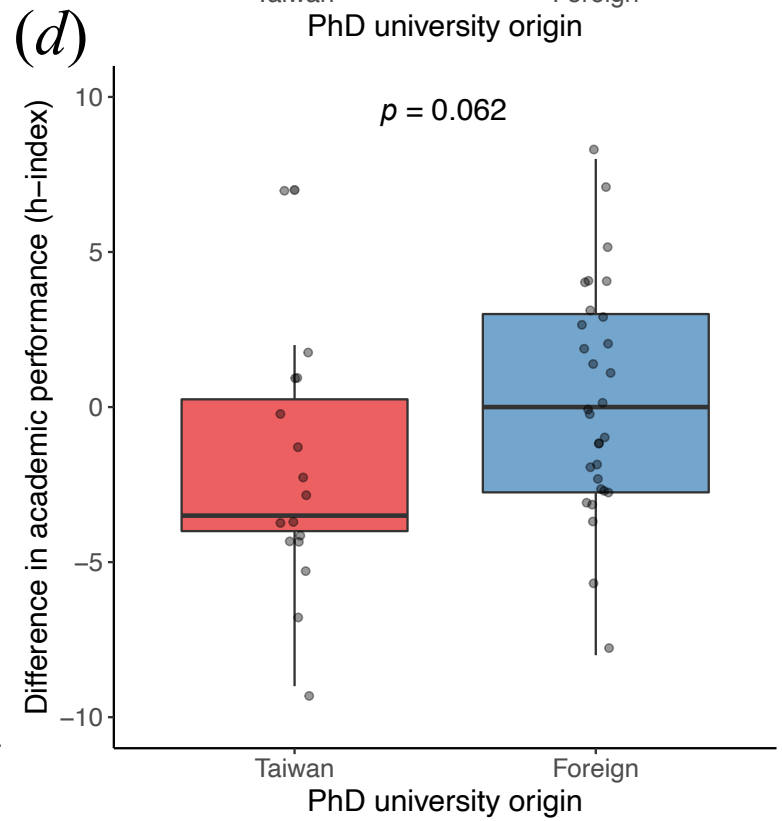
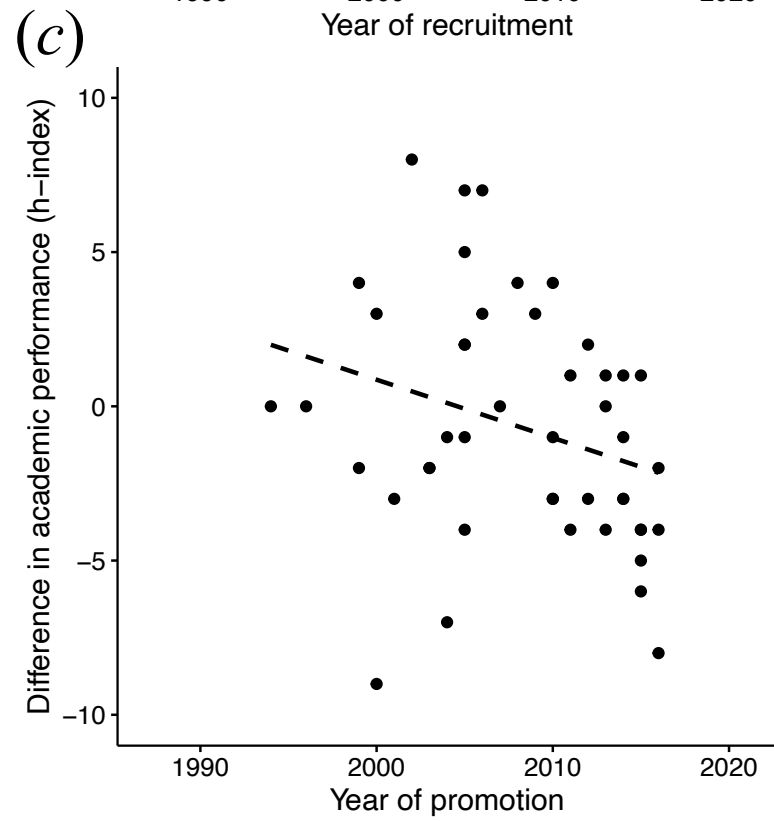
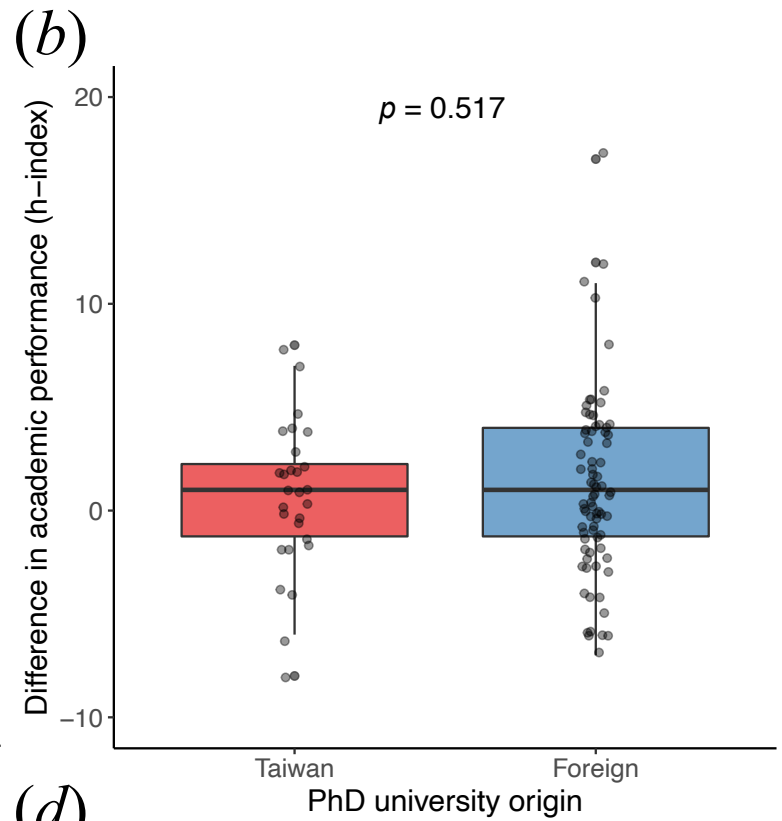
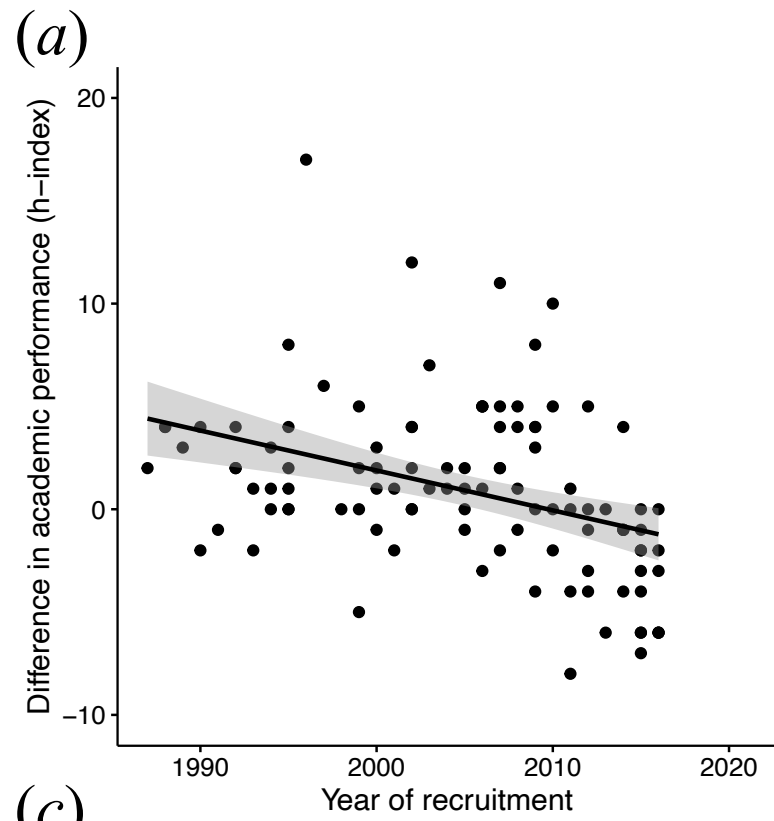
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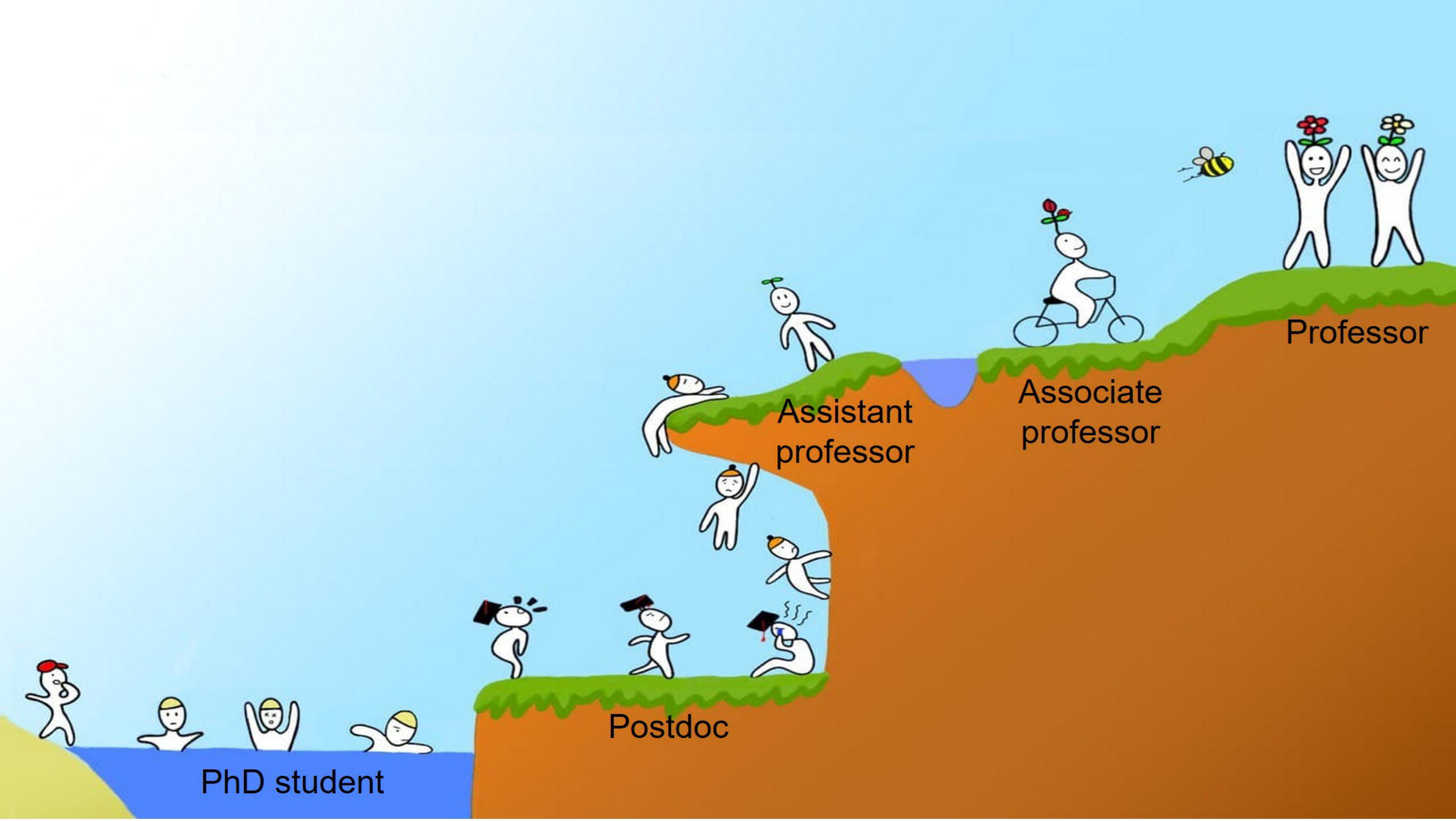
378 Figure S2. Distribution of the ranking of universities from which PIs obtained their  
379 PhD degrees. Dashed lines indicate medians of university ranking for Taiwanese  
380 (252) and foreign (108) PhD degrees.

381









PhD student

Postdoc

Assistant professor

Associate professor

Professor