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Increased academic performance and prolonged career duration among principal investigators in ecology and evolutionary biology in Taiwan

Gen-Chang Hsu¹, Wei-Jiun Lin², Syuan-Jyun Sun^{3,4*}

¹Department of Life Science, National Taiwan University, Taipei, Taiwan

²Institute of Ecology and Evolutionary Biology, National Taiwan University, Taipei, Taiwan

³Department of Ecology & Evolutionary Biology, University of Michigan, Ann Arbor, MI 48109, USA

⁴International Degree Program in Climate Change and Sustainable Development, National Taiwan University, Taipei 10617, Taiwan

ORCID iD

Gen-Chang Hsu: 0000-0002-6607-4382

Syuan-Jyun Sun: 0000-0002-7859-9346

*Corresponding author: Syuan-Jyun Sun; email: sjs243@ntu.edu.tw

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26 **Abstract**

27 Academic job markets have become increasingly challenging worldwide, yet it remains
28 poorly characterized how competitively-successful candidates should be and what the
29 underlying determinants of their success are. Focusing on the field of ecology and
30 evolutionary biology, we analyzed the academic performance (measured as h-index)
31 as well as the duration before recruitment as a new faculty member and promotion to
32 full professor of 145 principal investigators (PI) over the past 34 years in Taiwan. We
33 found that PIs had higher performance and longer duration before recruitment more
34 recently. Performance before promotion remained stable, whereas the duration
35 increased over time. The origin and prestige of doctorate had no effect on the
36 performance or duration either before recruitment or before promotion. We also found
37 that the difference in performance before and after recruitment (“After” performance
38 — “Before” performance) decreased in recent years, with PIs recruited in earlier years
39 maintaining their performance after recruitment while those recruited in later years
40 exhibiting a performance drop. While PIs performed equally well before and after
41 recruitment irrespective of doctorate origin, those with domestic PhD degrees showed
42 a decrease in performance after promotion compared to their counterparts with foreign
43 degrees. Taken together, our findings reveal a prolonged career duration for
44 researchers as a result of intensifying competition in academia, and highlight the
45 increasingly crucial role of academic performance, rather than PhD degree itself, in
46 determining academic success.

47

48 **Keywords**

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

51 **Introduction**

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

60

61 The intensifying competition for tenure-track positions, due to disproportionately high
62 numbers of applicants per position (Larson et al. 2014), has resulted in higher
63 expectations for academic performance shaped by a “*publish or perish*” culture
64 (Garfield 1996). A survey of evolutionary biologists recruited as junior researchers at
65 the National Centre for Scientific Research (CNRS) in France showed that academics
66 recruited in 2013 published nearly twice as many papers as those recruited in 2005
67 did (Brischoux and Angelier 2015). Additionally, although the minimum education
68 requirement for a tenure-track position is having a PhD degree, it has become
69 increasingly frequent for applicants to have one or even more postdoctoral
70 appointments. Consequently, many PhDs in STEM work as postdoctoral researchers
71 for a prolonged period of time and wait for future opportunities until they are
72 competitive enough in the academic job market (Swihart et al. 2016), whereas some
73 turn to alternative careers outside academia. In the aforementioned CNRS example,
74 Brischoux and Angelier (2015) also found that the time between first publication and
75 recruitment had increased from 3.25 to 8.0 years. The increase in postdoctoral training

76 time can be detrimental to not only the scientific community but also individuals
77 because this increases the age at which researchers become independent, and they
78 have to trade off families for research, with fixed-term and relatively low-paying jobs
79 (Acton et al. 2019).

80

81 Despite widely claimed that publication expectations and career duration have surged,
82 empirical quantification of the determinants regarding the change in academic profiles
83 over time remains understudied. In addition to research productivity, which directly
84 predicts the success of recruitment (van Dijk et al. 2014), the origin and prestige of
85 doctoral-granting institutes are critical indicators for academic employment as well
86 (van Dijk et al. 2014), especially in East Asian countries (Shin and Kehm 2013). With
87 the initiative to build world-class universities, many East Asian universities
88 preferentially recruit returnees who obtained PhD degrees from top-ranking
89 universities in Western countries. Hence, competition for limited tenure-track positions
90 is exacerbated when foreign PhDs are favored, leaving domestically-trained PhDs
91 deprived of career development opportunities (Chen 2021). Yet, whether and to what
92 extent publication expectations and career duration differ between domestic and
93 foreign PhDs, and if their academic productivities vary between pre- and post-
94 employment, remain largely unexplored.

95

96 In this study, we examined how academic performance as well as duration before
97 recruitment as a new principal investigator (PI) and promotion to full professor
98 changed over time, and how PhD university origin, PhD university ranking, and gender
99 affected the career success. Specifically, we tested the following questions: (1) Is the
100 academic performance for recruitment or promotion associated with the year of

101 recruitment, PhD university origin, ranking, and gender? (2) Is the duration before
102 recruitment or promotion affected by the year of recruitment, academic performance,
103 PhD university origin, ranking, and gender? (3) Does the academic performance of
104 PIs differ before and after recruitment or promotion? To address these questions, we
105 analyzed the data on 145 faculty members in the field of ecology and evolutionary
106 biology in Taiwan between 1987 and 2021. We aim to provide empirical evidence to
107 illustrate the temporal variations in researchers' publication performance necessary to
108 secure a faculty position and get a promotion, the role of PhD university and gender
109 in determining the success of academic employment, and how these factors contribute
110 to PIs' future academic performance.

111

112

113 **Materials and Methods**

114 *Data collection*

115 Between November and December, 2021, we surveyed tenure-track faculty members
116 at seven universities in Taiwan, all of which were qualified as research-intensive
117 universities and ranked top 150 in Asia according to 2022 QS Asia University Rankings
118 (<https://www.topuniversities.com/>). We also surveyed academics from Academia
119 Sinica, a leading academic institution in Taiwan. Together, these eight institutes
120 encompassed 34 academic departments/divisions that serve as tenure homes to the
121 field of ecology and evolutionary biology (including ecology, evolution, biodiversity;
122 see Appendix S1 for details). We excluded researchers in biomedical sciences
123 because publication rates, performance, and collaboration opportunities can vary
124 considerably among these fields (Laurance et al. 2013). A total of 145 PIs who had an
125 updated curriculum vitae online (e.g., institutional/personal websites or Open
126 Researcher and Contributor ID [ORCID]) were identified in our survey, with key
127 information on the university and year of PhD completion, the year of recruitment as a
128 new PI, the year of promotion to full professor, and gender, which is well-documented
129 as a key determinant of performance (Witteman et al. 2019). The university ranking
130 was determined based on 2022 QS World University Rankings. The duration before
131 recruitment as a new PI was calculated as the time between PhD completion and
132 landing a faculty position; the duration before promotion to full professor was
133 calculated as the time between landing a position and getting a promotion.

134

135 *Measurement of academic performance*

136 We collected data on academic performance, measured as h-index (Hirsch 2005),
137 from the Publish or Perish software using Google Scholar data, which are freely

138 available and more transparent for tenure reviews (Pauly and Stergiou 2005). We
139 included peer-reviewed papers and book chapters regardless of authorship for
140 calculation of h-index, while PhD theses and conference presentations were excluded.
141 Although other matrices, such as the number of publications and citations, are also
142 commonly used for measuring academic performance, they were both highly
143 correlated with h-index in our study (publications: $r = 0.91$, $p < 0.001$; citations: $r = 0.77$,
144 $p < 0.001$), which had also been found in previous studies (Laurance et al. 2013; Ryan
145 Haley 2012). We thus focused on h-index, a widely accepted measure of academic
146 success that incorporates the assessment of quantity (number of papers) and quality
147 (citations) of publications (Glänzel 2006).

148

149 We calculated h-index within the five-year interval both before and after the year of
150 recruitment and promotion, generating up to four h-indexes for each PI. We used the
151 duration of five years because this time span is commonly used by institutes to
152 evaluate the most recent academic performance both for recruiting a new PI and for
153 promotion to full professor. The publications and citations during the year of
154 recruitment and promotion were considered as the performance before recruitment
155 and promotion because these publications, either as published papers or manuscripts
156 “accepted” or “in press”, would most likely contribute to the evaluation of academic
157 performance prior to successful recruitment and promotion. For example, a PI who
158 started a position in 2010 would have an h-index measured for publications between
159 2006 and 2010 (i.e., “Before” h-index for recruitment), and another h-index measured
160 for publications between 2011 and 2015 (i.e., “After” h-index for recruitment). We did
161 not include “After” h-indexes for PIs who were recruited or promoted less than five
162 years so that all performances have comparable duration.

163

164

Statistical analyses

165 (1) Academic performance before recruitment/promotion. To examine how various
166 factors affected the academic performance before recruitment as a new PI and
167 promotion to full professor, we fit linear mixed-effects models (LMMs) with PhD
168 university origin (binary variable: Taiwan vs. Foreign), PhD university ranking, year of
169 recruitment/promotion, gender, and all single-factor interactions with year as fixed
170 effects, the institute (department) nested within university as random effects, and the
171 “Before” h-index for recruitment/promotion as the response.

172

173 (2) Duration before recruitment/promotion. To examine how various factors affect the
174 duration before recruitment and promotion, we fit LMMs with PhD university origin,
175 PhD university ranking, year of recruitment/promotion, gender, the “Before” h-index
176 for recruitment/promotion, and all single-factor interactions with year as fixed effects,
177 the institute (department) nested within university as random effects, and the duration
178 before recruitment/promotion as the response.

179

180 (3) Difference in academic performance before and after recruitment/promotion. To
181 compare the academic performance before and after recruitment and promotion, we
182 fit LMMs with PhD university origin, PhD university ranking, year of
183 recruitment/promotion, gender, and all single-factor interactions with year as fixed
184 effects, the institute (department) nested within university as random effects, and the
185 difference between “After” and “Before” h-index for recruitment/promotion (i.e., “After”
186 h-index — “Before” h-index) as the response.

187

188 LMMs were performed using the package “lme4” (Bates et al. 2015); post-hoc pairwise
189 comparisons were performed using the package “emmeans” (Lenth 2021). Response
190 variables (h-index and duration before recruitment/promotion) were log-transformed
191 prior to analyses to meet the assumption of normality. The assumption of
192 independence and equal variance were both assessed using the residual plots. Non-
193 significant interactions ($p > 0.05$) were dropped from our final model results. All
194 analyses were performed in R version 4.1.2 (R Development Core Team 2014).
195

196 **Results**

197 In total, we collected data on 145 tenure-track faculty members, of which 44.8% were
198 full professors, 24.8% were associate professors, and 30.3% were assistant
199 professors. Nearly half of the PIs obtained their PhD degrees from the USA (45.5%),
200 followed by Taiwan (33.1%), and relatively few from the UK (4.8%) and other countries
201 (Fig. 1). The PhD universities varied widely in the ranking of prestige among 73
202 universities from 16 countries (Fig. 2). The gender difference was substantial, with
203 males (112) being around four times as many as females (33).

204

205 The academic performance before recruitment (“Before” h-index for recruitment) was
206 higher for PIs who landed tenure-track positions more recently, whereas the
207 performance for promotion to full professor (“Before” h-index for promotion) remained
208 constant over years (Table 1, Fig. 3a–b). Although male PIs had on average higher
209 performance than female PIs before recruitment, no such gender difference was found
210 before promotion. PhD university origin and ranking had no effect on the performance
211 either before recruitment or before promotion (Table 1).

212

213 PIs who landed positions more recently spent more time post-PhD before recruitment,
214 while higher academic performance reduced this duration (Table 1, Fig. 3c). On the
215 other hand, PIs also spent more time before promotion to full professor in recent years,
216 yet the duration was not related to the performance (Table 1, Fig. 3d). PhD university
217 origin, ranking, and gender had no effect on the duration either before recruitment or
218 before promotion (Table 1).

219

220 The difference in academic performance before and after recruitment (“After” h-index
221 — “Before” h-index) decreased for PIs who landed positions more recently, while PhD
222 university origin, ranking, and gender had no effect on the performance difference
223 (Table 1, Fig. 4*a–b*). In contrast, the difference in performance before and after
224 promotion to full professor was not associated with the year of promotion, PhD
225 university ranking, or gender, yet the difference tended to be higher for PIs with foreign
226 degrees compared to those with Taiwanese degrees (Table 1, Fig. 4*c–d*).

227

228

229 **Discussion**

230 Overall, we showed that the academic performance of PIs before recruitment as new
231 faculty members increased over years, whereas the performance before promotion to
232 full professor remained relatively unchanged. We also found that the duration both
233 before recruitment and before promotion increased in recent years. These results
234 provide empirical evidence supporting the suspicion that publication requirements and
235 expectations have risen over time in the field of ecology and evolutionary biology in
236 Taiwan, in line with many academic job markets worldwide (Rawat and Meena 2014;
237 Warren 2019).

238

239 The increase in academic performance of PIs before recruitment suggests that the
240 academic job market might have become increasingly competitive over time, which is
241 likely driven by a relatively lower demand for tenure-track professors compared to the
242 supply of new PhDs (Larson et al. 2014). Consequently, the duration post-PhD may
243 be prolonged if the applicants are not competitive enough. However, higher academic
244 performance could help shorten the time to land a position. Therefore, it would be
245 important for early-career researchers to home in on publications in order to
246 demonstrate their competence for academic success. In contrast, the performance of
247 PIs before promotion to full professor remained similar over years, suggesting that the
248 requirements for promotion might not have changed much over time. Interestingly, the
249 time to full professor has lengthened in recent years but was not affected by academic
250 performance, possibly due to increasing consideration of accomplishments such as
251 teaching and administrative services by employment institutes in addition to research
252 outputs. Such different patterns in academic performance and career duration
253 between recruitment and promotion phase are likely due to applicants facing

254 increasing competition with others during recruitment and thus higher performance
255 would be advantageous for securing a position, whereas getting a promotion depends
256 mainly on individual PI meeting the institutes' requirements rather than comparing with
257 others' performance.

258

259 We found that the average performance of a new male PI was higher than that of a
260 new female PI. This may result from higher standards for evaluating the suitability of
261 a potential faculty member for males compared to females (Symonds et al. 2006).
262 Alternatively, it could be due to employment institutes striving to recruit female
263 applicants to enhance gender equity despite the likelihood of female applicants having
264 a lower performance than their male competitors, which can be exacerbated by implicit
265 bias and stereotype threats that females face in biological sciences (Salerno et al.
266 2019). However, the performance expectations for promotion to full professor did not
267 differ between male and female PIs, indicating that after recruitment, especially when
268 gender equality is enhanced, individual performance is the key to further promotion
269 regardless of gender. Contrary to a previous study showing that researchers from
270 higher-ranked institutes become PIs faster compared to those from lower-ranked
271 institutes (van Dijk et al. 2014), we found no evidence of PhD university origin and
272 ranking influencing the career duration either before recruitment or before promotion.
273 Instead, our results suggest that academic performance during PhD and/or post-PhD
274 period may be more important in determining the academic success compared with
275 the prestige of education itself.

276

277 The difference in performance before and after recruitment decreased over years.
278 Specifically, PIs in earlier years had on average higher h-indexes after recruitment

279 than before recruitment, yet such a “performance boost” has declined in recent years.
280 This could be due to increasing teaching and administrative demands of new PIs,
281 reducing their time available for research. Surprisingly, we found that PIs performed
282 consistently before and after recruitment regardless of their PhD university origin or
283 ranking. However, PIs with domestic PhD degrees did show a decrease in
284 performance after promotion to full professor compared to before promotion, whereas
285 PIs with foreign PhD degrees had relatively consistent performance before and after
286 promotion. One possible explanation is that the training and experiences from foreign
287 universities may have equipped those PIs with greater professional abilities, which
288 together with international connections and collaboration opportunities, help maintain
289 their performance.

290

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

304 carefully when applied to the fields outside the scope of this study. In conclusion, our
305 findings confirm that succeeding in academia has become more challenging, with
306 publication requirements and career duration both increasing over years. In the face
307 of increasingly competitive academic job markets, boosting performance is a key to
308 career success in academia.
309

310 **Statements and Declarations**

311 • **Competing interests**

312 The authors declare no competing interests.

313

314 • **Footnotes**

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

319

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322

323 • **Authors' contributions**

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

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395 Tables and Figures

Table 1. Results of the LMMs (type III sum of squares) on academic performance before recruitment/promotion (“Before” h-index), career duration before recruitment/promotion, and difference in performance before and after recruitment/promotion (“After” h-index – “Before” h-index)

Response	Predictor	χ^2	d.f.	<i>P</i> *
Academic performance (recruitment)	Year of recruitment	74.68	1	< 0.001
	Gender	5.73	1	0.02
	PhD university origin	1.42	1	0.23
	PhD university ranking	0.45	1	0.50
Academic performance (promotion)	Year of promotion	0.97	1	0.32
	Gender	0.07	1	0.79
	PhD university origin	0.06	1	0.81
	PhD university ranking	1.06	1	0.30
Duration (recruitment)	Year of recruitment	43.08	1	< 0.001
	Academic performance	6.10	1	0.01
	Gender	0.78	1	0.38
	PhD university origin	1.01	1	0.32
	PhD university ranking	1.82	1	0.18
	Academic performance x Year of recruitment	6.06	1	0.01
Duration (promotion)	Year of promotion	7.03	1	0.01
	Academic performance	1.87	1	0.17
	Gender	3.18	1	0.08
	PhD university origin	1.96	1	0.16
	PhD university ranking	0.62	1	0.43
Difference in performance (recruitment)	Year of recruitment	15.40	1	< 0.001
	Gender	0.06	1	0.80
	PhD university origin	0.42	1	0.52
	PhD university ranking	0.38	1	0.54
Difference in performance (promotion)	Year of promotion	2.96	1	0.09
	Gender	0.81	1	0.37
	PhD university origin	3.48	1	0.06
	PhD university ranking	0.51	1	0.47

* *P* values < 0.05 are highlighted in bold.

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

399

400 **Fig. 2** Distribution of the ranking of universities from which PIs obtained their PhD
401 degrees. Dashed lines indicate medians of university ranking for Taiwanese (252) and
402 foreign (108) PhD degrees

403

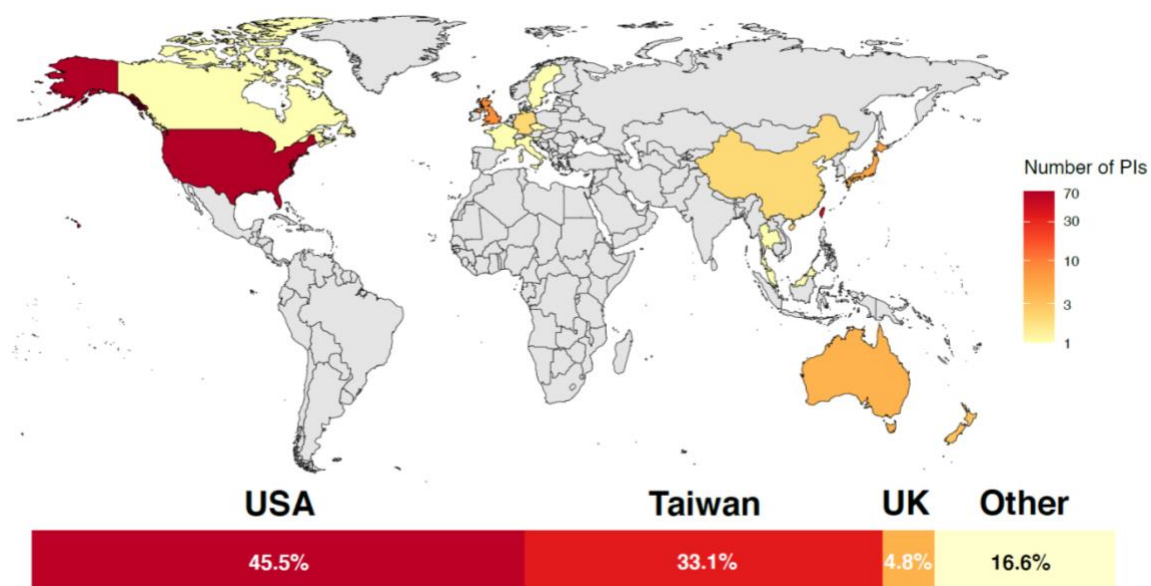
404 **Fig. 3** Temporal variations in academic performance (*a & b*) and career duration (*c &*
405 *d*) before recruitment and promotion. Each point represents an individual PI, with
406 points in (*c*) colored by “Before” h-index. Solid/dashed lines represent significant/non-
407 significant relationships predicted from the LMMs; shaded areas indicate 95%
408 confidence intervals

409

410 **Fig. 4** Difference in academic performance before and after recruitment (*a & b*) and
411 promotion (*c & d*) (“After” h-index – “Before” h-index) in relation to the year of
412 recruitment/promotion and PhD university origin. Each point represents an individual
413 PI. Solid/dashed line represents significant/non-significant relationships predicted
414 from the LMMs; shaded areas indicate 95% confidence intervals

415

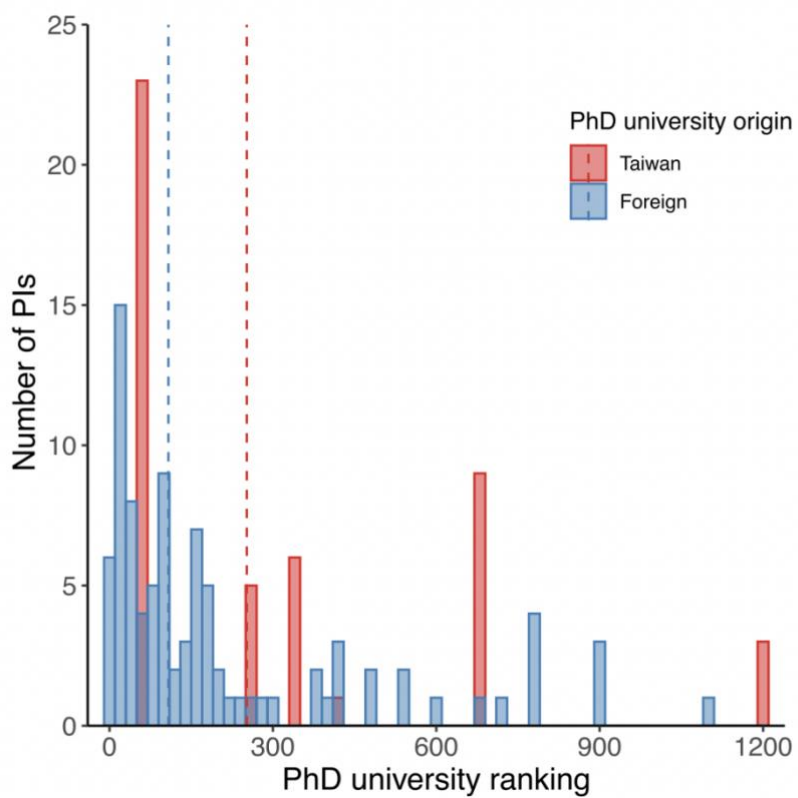
416 **Fig. 1**



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419 **Fig. 2**

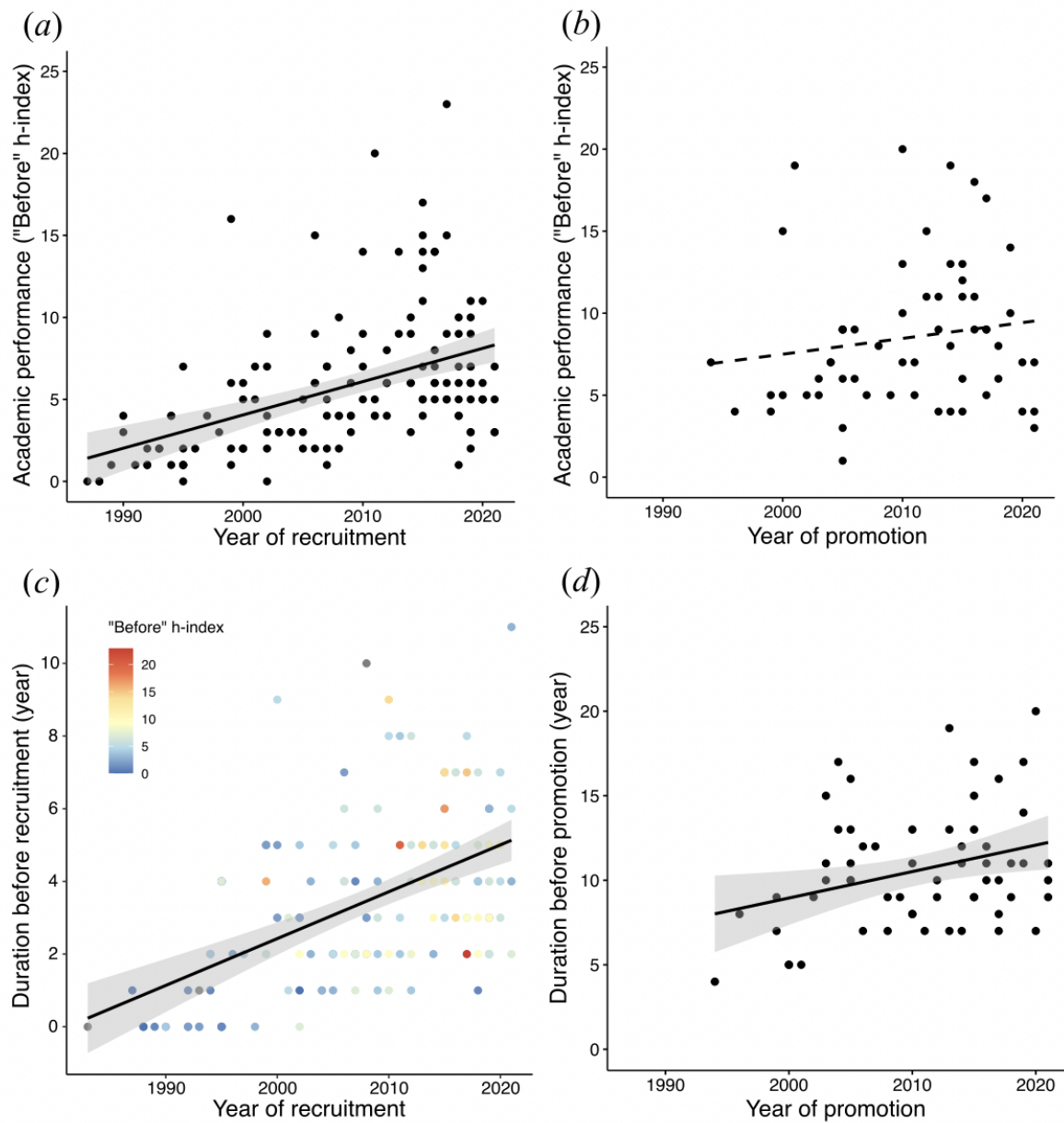


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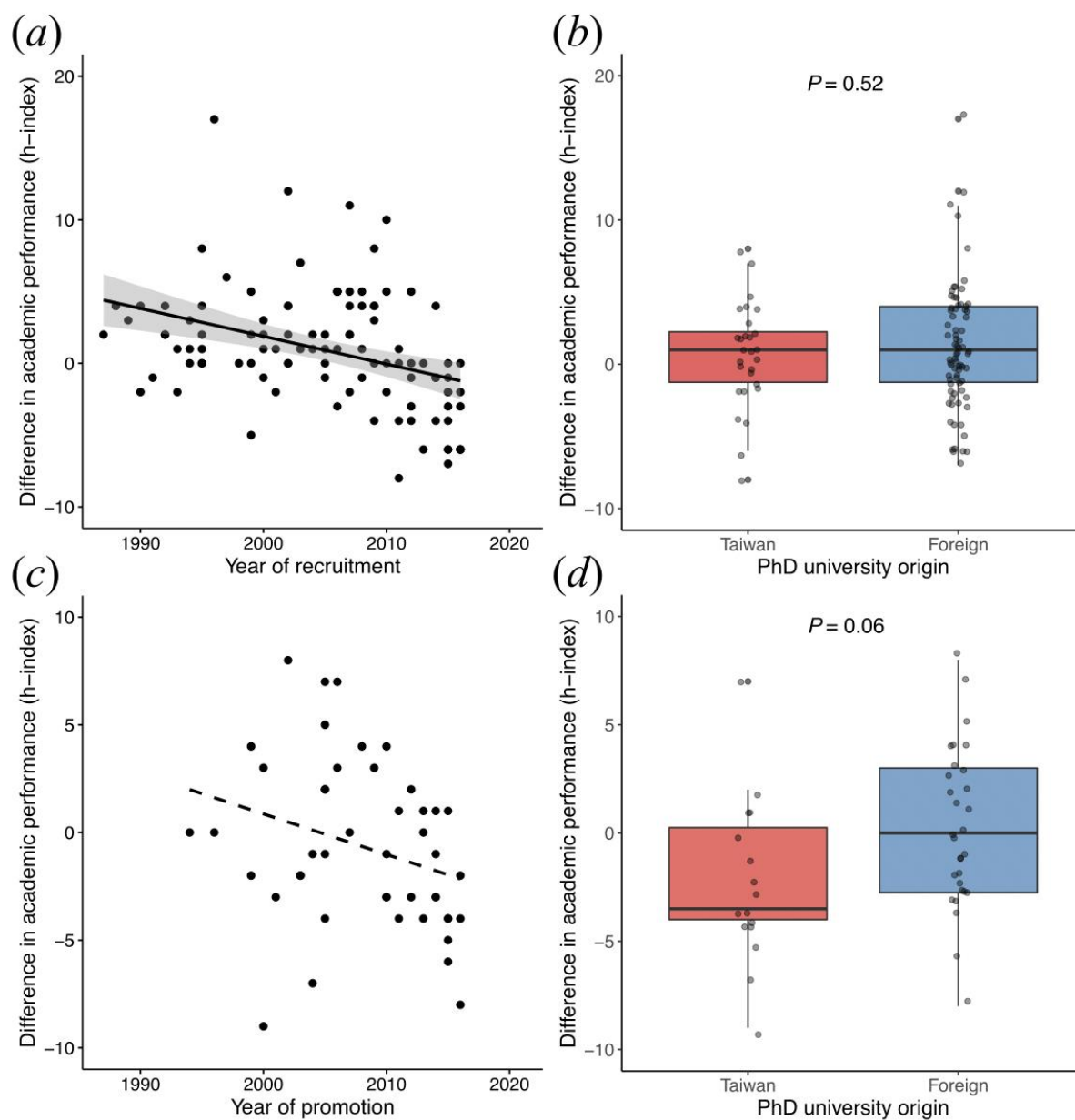
423 **Fig. 3**



424

425 **Fig. 4**

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