Academic and Demographic Characteristics as Predictors of Scholarly Productivity in the Israeli Academia

Maor Weinberger[1], Maayan Zhitomirsky-Geffet[1], and Dan Bouhnik[1,2]

[1] Bar-Ilan University, Ramat-Gan, Israel
[2] Jerusalem College of Technology, Jerusalem, Israel
maor89@gmail.com

Abstract. In this study we investigated the influence of various researchers' characteristics, such as faculty, department, gender and seniority, on their scholarly productivity. A quantitative research was conducted with 601 professors with tenure from two leading Israeli universities, in order to construct a comprehensive model for assessment and prediction of the scholarly productivity. We found a great variability in seniority and productivity of the examined professors. In addition, a multivariate linear regression showed significant differences between the examined faculties. The faculty of Life Sciences was the most scholarly productive, while Social Sciences was the least scholarly productive faculty. Overall, there was a positive influence of academic seniority on scholarly productivity, however, scholars with over twenty years of seniority appeared to be less productive than those with the middle level seniority. One of the most interesting findings was gender differences of the scholarly productivity distribution. Contrary to the past research, we found that women were more productive than men. This is a first large-scale quantitative research of senior scholars in Israel which sheds some light on the productivity evaluation and its influence factors in the Israeli academia.

Keywords: Scholarly Productivity, Academic Productivity, Researcher Evaluation, Gender, Seniority, Faculty, Bibliometrics, Scientometrics, H-index.

1 Introduction

The academic impact of researchers is measured by various indicators. The traditional ones are the number of publications and citations which determine the researcher's status in the academia [1]. Hirsch [2] created an h-index that combines between these two parameters. In a later study [3], he showed that this index is the best indicator to predict the future productivity of researchers. Numerous variants of h-index have been proposed in the literature [4-6]. However, all of those indexes correlate with h-index [7]. Hence, two novel indexes were recently proposed to address some of the problems of h-index: the χ-index [8] – "determined by the largest area rectangle that fits under the citation curve" and the rec-index (or rectangle-index) – defined as the square of the χ-index [9]. The development and evaluation of those indexes was based on 35,000 citation profiles from the Google Scholar database, across various disciplines, taken from the work of Radicchi and Castellano [10].

Numerous studies have investigated the factors of influence on academic productivity [11-19]. Simonton [20] developed a model, which shows that the growth or decrease in productivity may stem from two opposite effects that vary with scholars' seniority. On the one hand, there is a decrease in the scholars' ability to produce new ideas as their career progresses. On the other hand, their increased experience and reputation may lead to greater knowledge, effective problem-solving methods and improved probabilities of obtaining grants and research funding [21]. Abramo et al. [21] who investigated the influence of age and seniority among 13,000 full professors from various disciplines in Italy, active within the years 2006-2010, found that scholarly productivity decreases with age. However, there is a positive influence of academic seniority on the productivity. Thus, the earlier the scholars get their promotion to full professor, the more productive they become. Likewise, Campbell et al. [11] found among 986 faculty-member neurosurgeons that scholarly productivity is increased with academic rank. They also found significant differences between scholars from various fields of study, within the general field of neurosurgery.

Several studies showed gender differences in terms of scholarly productivity, with men being more productive than women [11, 16-17, 19, 22-24]. Tomei et al. [18], who investigated this issue among 1,052 academic neurosurgeons, also found gender variations with men being more scholarly productive than women, however these variations disappeared when subjects were separated by academic rank. Gender differences were even found to be less pronounced in terms of quality and contribution intensity [22]. Likewise, Eloy et al. [12] found that women productivity rates increased and even equaled to or surpassed those of men later in their careers. This was explained by motherhood and child care [24-25] that are more prominent for women at their early career period. Another examined factor of influence was co-authorship. It was found by numerous studies that greater academic collaboration leads to higher scholarly productivity [13, 26-30]. Studies that compared scholarly productivity across disciplines found that publication rates of natural scientists exceed those of social scientists and humanists [31-35]. Henderson and Brestky [14] investigated predictors of scholarly productivity in the field of emergency medicine and found an advantage for scholarly productivity of a certain academic program over the others, dependent on the geographic location. Pagel and Hudetz [15] found that scholars from departments with government funding were more productive than scholars from departments with no government funding.

This article aims to investigate the influence of a variety of academic and demographic characteristics, such as faculty, department, gender and seniority, on scholarly productivity of Israeli researchers. As far as we know, this is the first large-scale data-driven research conducted with 601 faculty members from a variety of departments of two universities in Israel that aims to construct a comprehensive model for assessment and prediction of scholarly productivity. Another research goal was to explore the productivity variability of professors in the Israeli academia. As opposed to previous research reviewed above, this study's population was relatively homogeneous in terms of the academic rank (professors with tenure), and basic characteristics of the academic instuitions (two large leading universities in Israel from the centre of the country). Hence, one could expect to observe some uniformity in

productivity and seniority, as imperative determinants for the academic ranking of professors in Israel.

Unlike past research that focused on a certain characteristic, or studied scholar activity within a predefined timeframe in a narrow scientific domain, this research explored a variety of prominent academic and demographic factors, across 28 academic departments from five different faculties. The timeframe was determined by the academic activity of the examined scholars.

2 Methods

This study was conducted using a quantitative data-driven method that applies standard statistical analyses on the collected data. The final corpus of the study consisted of 601 academic scholars, sampled from two major academic institutions in the centre of Israel: Bar-Ilan University and Tel-Aviv University.

The data collection process was two-phased. All faculty members with an academic rank of professor (including Emeritus) in the faculties of Life Sciences, Social Sciences, Exact Sciences, Law and Engineering were identified and their details were extracted from the universities' websites. The rank limitation of professor was made in order to create a dataset of researchers with similar academic level and experience and due to their relatively higher scholarly productivity rates. At the first phase, 1,008 professors were found. For each of them, we collected a name, department, faculty, institution and academic rank (professors are titled as such on the universities' websites). Note that there are four academic ranks in Israel: lecturer, senior lecturer, associate professor and full professor, while scholars with the two latter ranks are officially titled as professors and all of them have tenure. Then, for the accuracy of scholar identification some of the researchers were ruled out according to the following nominal restrictions:

- Multiple first names or surnames (e.g. John X. Doe or John Doe-Roe).
- Surname that can also be used as a first name.
- Common Israeli or International name.

Once the initial faculty list has been created, the academic data of each scholar was retrieved from the Web of Science database (using his/her name and affiliation). Web of Science is considered to be the most reliable database in terms of research activity and is the determinant for academic promotions in the Israeli academia. The following items were collected: total publications, total citations and h-index. Those were used to measure scholarly productivity. Notably, at this stage scholars with less than 10 publications were excluded from the study sample. We also extracted the first publication year of each researcher from the Web of Science to determine his/her relative seniority in the academic world. Finally, each researcher in the database was assigned a unique ID number and their names were deleted from the database for personal information privacy reasons.

Table 1 below presents the demographic distribution of the sample. Figure 1 presents the sample distribution by department.

Table 1. Demographic distribution of the sample

	Variable	N	Percentage %
Gender	Male	498	82.9%
	Female	103	17.1%
Academic Institution	Bar-Ilan University	204	33.9%
	Tel-Aviv University	397	66.1%
Faculty	Life Sciences	120	20%
	Social Sciences	120	20%
	Exact Sciences	250	41.6%
	Law	17	2.8%
	Engineering	94	15.6%

Table 1 shows that the vast majority of the Israeli professors in the examined departments are men (82.9%). The gender distribution is a bit more balanced in Social Sciences (M= 63%, F= 37%) than in the other faculties. The largest examined faculty is Exact Sciences (41.6%).

Figure 1 shows that the largest examined departments were: Engineering, Physics & Astronomy and Chemistry.

To investigate influence factors of the scholarly productivity, we performed a multiple linear regression analysis, using an academic institution, a faculty, a department, seniority (calculated according to the first publication year) and gender (determined by researchers' names and photos on the university websites) as independent variables. For the purposes of the statistical analysis, Engineering was unified with Exact Sciences and Law and Management were unified with Social Sciences. To obtain normal distribution, the dependent variables were logarithmically transformed and subsequently used in the regression model [36].

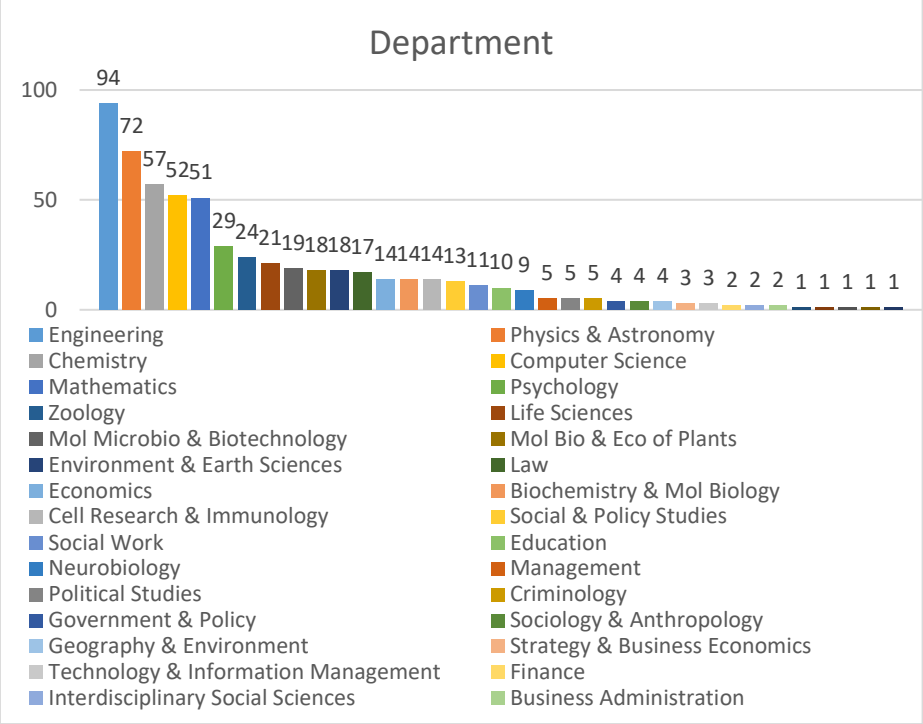

Fig. 1. Sample distribution by department

3 Results

The mean publication number for a professor in the corpus was 56.8 (±53.21), the mean citation number was 1492.81 (±2371.44), and the mean h-index was 15.66 (±10.26). Figures 2, 3 and 4 present the publication, citation and h-index rate distributions of the sample, respectively. As can be observed from the obtained results, there was a great variability in professors' productivity by all three indicators. For 80% (450 out of 601) of the professors the publication number was 70 or less, the number of citations was below 1,600 and h-index was lower than 20, while for the top productive scholars the maximal publication rate was seven times higher (around 500), the citation rate was over 18,000 and h-index exceeded 60. Strong Pearson correlations were obtained ($p<0.001$) between publications and citations ($r=0.74$); publications and h-index ($r=0.80$); and citations and h-index ($r=0.94$). This is in accordance with the findings of the past research [8-9].

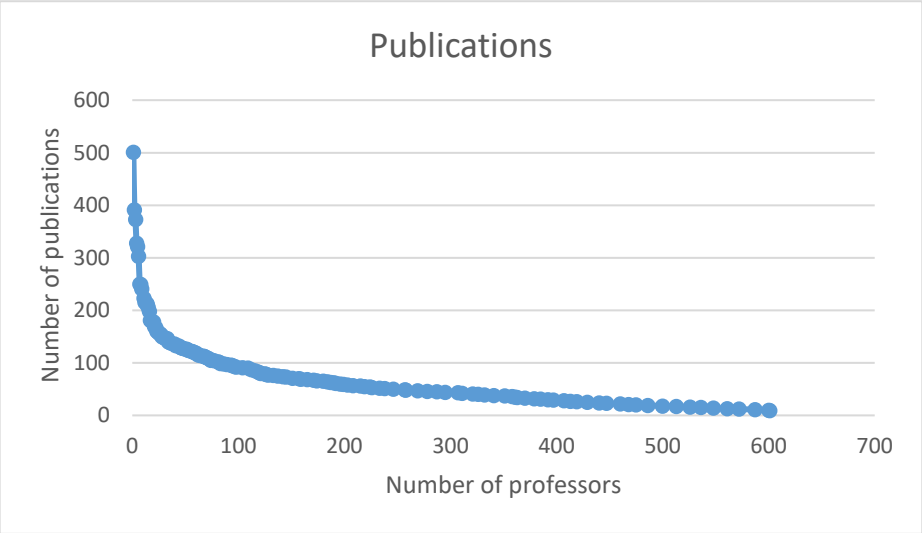

Fig. 2. Publication rate distribution, measured as the number of professors with at least a corresponding number of publications.

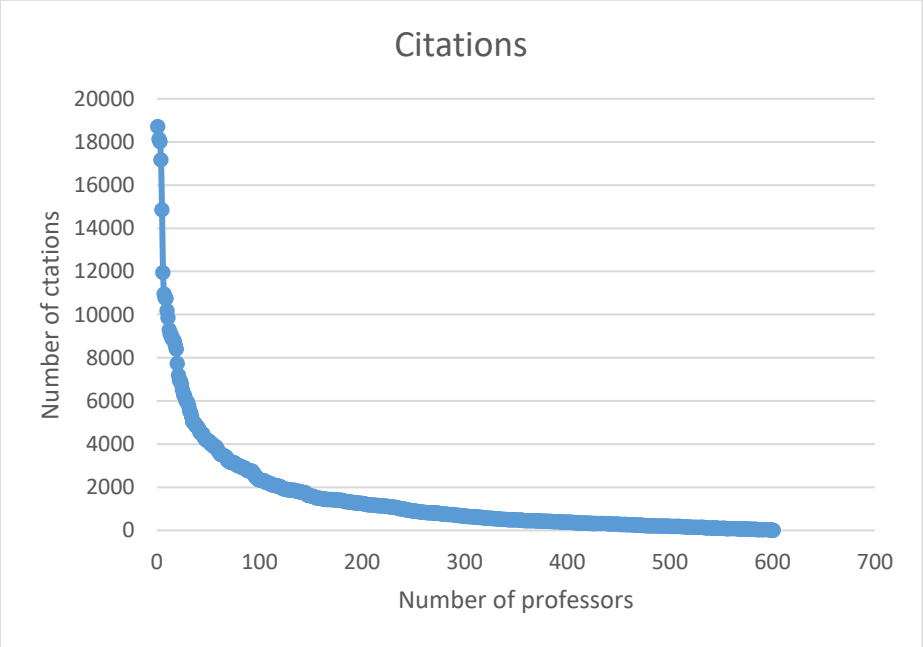

Fig. 3. Citation rate distribution, as the number of professors with at least a corresponding number of citations.

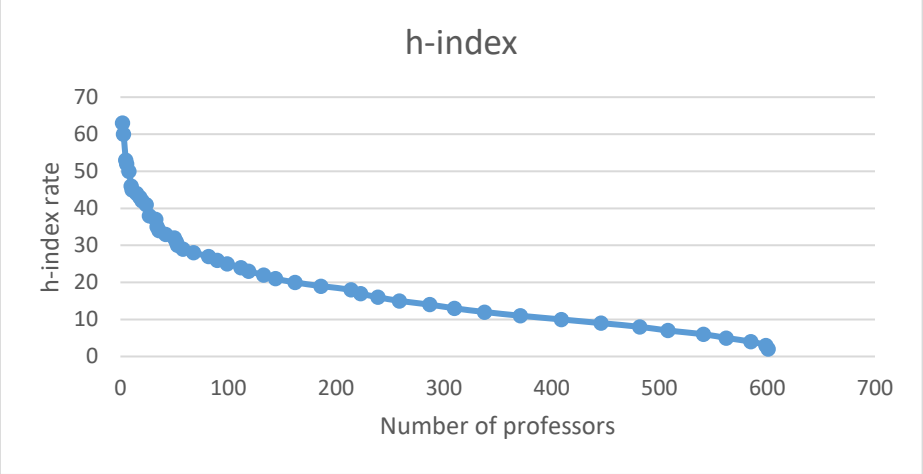

Fig. 4. h-index rate distribution, as the number of professors with a corresponding or higher h-index value.

Bar-Ilan University was found to produce slightly more publications per scholar on average, compared to Tel-Aviv University (57.03 vs. 56.69), however Tel-Aviv University had the lead in terms of average citations (1547.62 vs. 1386.13) and average h-index (16.31 vs. 14.39). According to the data extracted from Web of Science, the most productive faculty was Life Sciences, while Law was the least productive faculty. The most scholarly productive department was Molecular Microbiology and Biotechnology from Tel-Aviv University. Life Sciences in general and Biology in particular were found in the past among the highest scholarly productive fields [31-35].

In terms of gender, we found that women were more scholarly productive than men: citations (F=1547.17, M=1485.35, on average); h-index (F=16.67, M=15.46, on average), even though they publish less (F=55.86, M=57.11, on average). These results differ from most of the past research [11, 16-17, 19, 22-24] that showed consistent dominance of men in terms of scholarly productivity.

Figures 5, 6 and 7 present the scholarly productivity rate distributions by seniority. The variance in professors' seniority was also very high, spanning from 6 to 31 years (M=18.91, SD=5.79). Surprisingly, seniority was not found to be significantly correlated with any of the examined scholarly productivity variables: publications, citations and h-index. This differs from Abramo et al. [21], who found positive influence of academic seniority on the productivity.

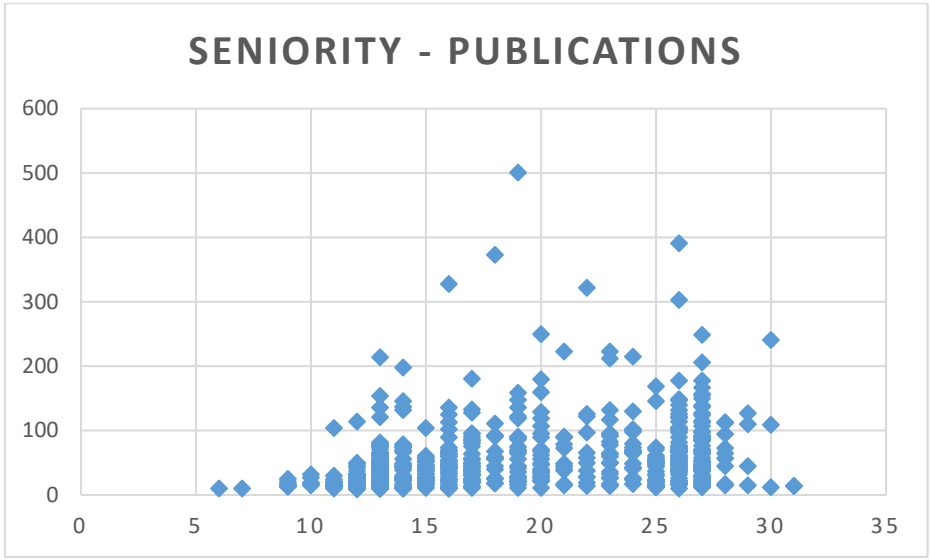

Fig. 5. Publication rate distribution by seniority

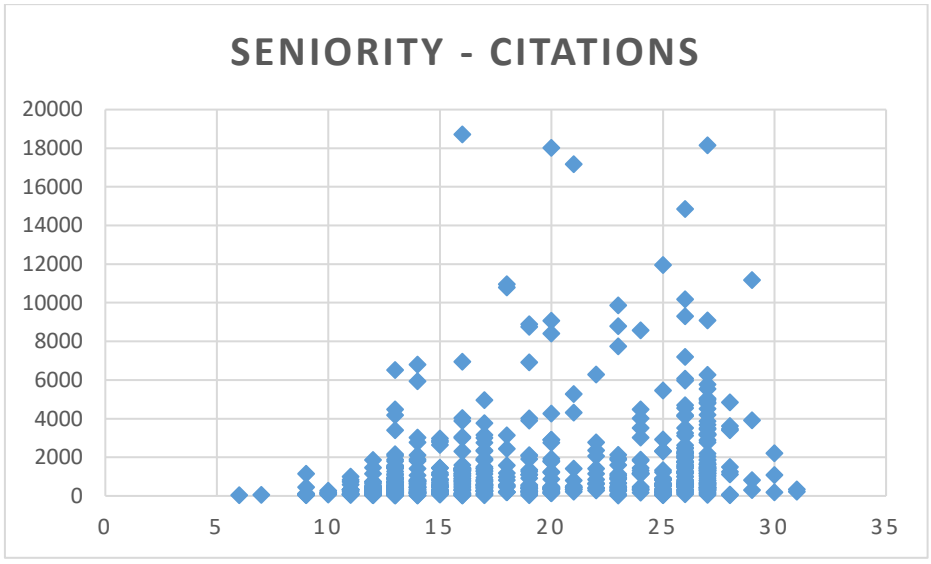

Fig. 6. Citation rate distribution by seniority

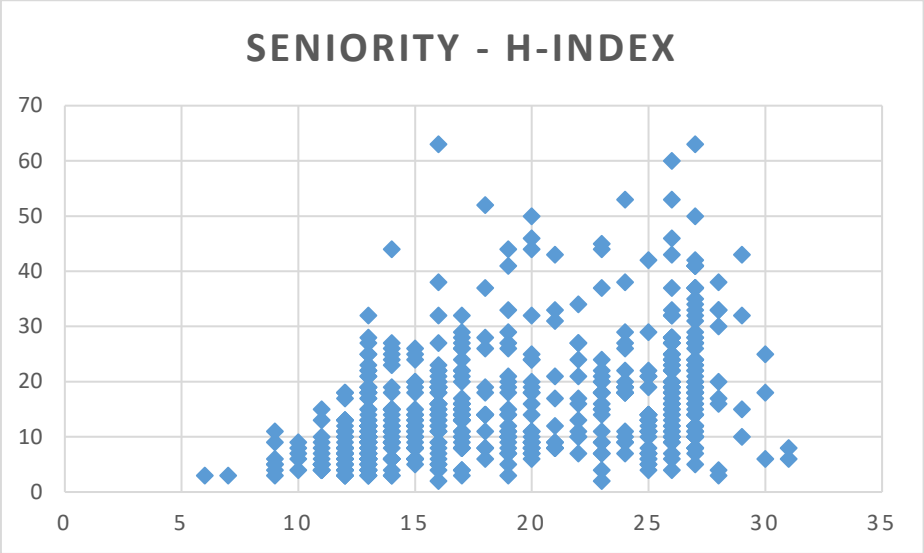

Fig. 7. h-index rate distribution by seniority

In addition, we found significant differences between the faculties for every tested scholarly productivity variable. Table 2 below presents the means, standard deviations and significance of the differences between the faculties.

Table 2. The means, standard deviations and significance of the differences between the faculties

Dependent variable	Faculty	Mean (SD)	F df = 2, 598	p
Total publications	Life Sciences	68.88 (48.08)		
	Exact Science	60.62 (58.14)	14.43	0.001
	Social Sciences	36.64 (37.01)		
Total citations	Life Sciences	2761.96 (2868.45)		
	Exact Science	1296.90 (2327.14)	24.87	0.001
	Social Sciences	873.04 (1430.88)		
h-index	Life Sciences	23.32 (10.32)		
	Exact Science	14.63 (9.56)	54.50	0.001
	Social Sciences	11.53 (8.33)		

Table 2 demonstrates that there were significant differences in all scholarly productivity variables between the three faculties. Life Sciences was the most scholarly productive faculty and Social Sciences was the least productive faculty.

Finally, we computed a multivariate linear regression model for predicting researcher's h-index as a dependent variable representing scholarly productivity. The regression was found significant $F(5,595)=39.92$, $p<0.001$, with the predictor variables explaining 25% of the variance ($R^2=0.25$). As can be observed from Table 3, the most significant influential factors were gender (women have higher h-index than men), and faculty (h-index significantly increases for Life Sciences and decreases for Social Sciences).

Table 3. The linear regression coefficients for predicting scholar's h-index.

	Dependent variable: h-index			
Predictors	**β**	**SE**	**B**	**t**
Gender	0.01	0.03	0.06	***2.28**
Academic Institution	-0.02	0.02	-0.01	**-0.54**
Faculty - Life Sciences vs. others	-0.18	0.03	-0.12	****-4.14**
Faculty - Social Sciences vs. others	0.20	0.03	0.13	****5.12**

***p<0.05, **p<0.01**

4 Conclusions

This research examined the influence of multiple demographic and academic characteristics on scholarly productivity. Interestingly, despite the similar academic rank and tenure, there was a great variability in the productivity distribution of the study sample. This might indicate that some additional factors are considered for scholar evaluation in Israeli universities rather than academic productivity (publication and citation levels). Our findings show that the most productive scholars are mid-career life scientists.

One of the most interesting findings was gender differences in scholarly productivity distribution. While in most of the previous research, men were found to be more scholarly productive than women [11, 16-17, 19, 22-24], our regression model indicates significant differences between the genders, with women being more productive than men. Thus, we conclude that the amplification of senior female scholars (who currently constitute a small minority) in Israeli academic institutions may lead to significantly better scholarly productivity and improve the country's academic ranking in the world.

Notably, the findings described above are limited by the coverage and accuracy of the Web of Science database. Further research will extend the analysis to include other scientific databases, such as Scopus and Google Scholar, and perform an in-depth investigation of the top productive scholars to develop a predictive model for becoming a leading scholar in various academic fields.

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