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Original Article

Does the nuclear engineering field perform worse in utilizing women? Evidence from South Korea

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ABSTRACT

Despite its remarkable socioeconomic development, South Korea underperforms in terms of female labor force participation and women in leadership positions. As women appear to avoid nuclear engineering, we aim to evaluate its relative performance in attracting women to its labor force compared to other college majors. Using college-major level information from 2000, we test whether the female faculty share in nuclear engineering is lower than its counterparts. Although nuclear engineering has one of the lowest female faculty shares, its share exceeds that of agricultural science, business and economics, chemical engineering, chemistry, civil engineering, and industrial engineering once we properly control for gender composition among students and other compounding factors. In other words, once female students major in nuclear engineering, they are less likely to leave their fields compared to their counterparts in other disciplines. This result implies that if the nuclear engineering field aims to attract more women to its workforce, it is important to target them from the early stage of their careers.

1. Introduction

Despite the increasing number of women pursuing higher education and entering the labor market, the fields of science, technology, engineering, and mathematics (STEM) remain male-dominated. The nuclear industry is a particularly notable example. According to the Nuclear Energy Agency (NEA) within the Organisation for Economic Co-operation and Development (OECD), women constitute only 24.9% of the nuclear workforce in its 17 member countries [1].[1] To improve female representation, the International Atomic Energy Agency (IAEA) has initiated several programs, including the Women in Nuclear Security Initiative (WINSI) and the Marie Sklodowska-Curie Fellowship Programme, while the NEA collects data on women in the nuclear sector globally to develop policies and practices that improve gender balance in the field [2,3]. On the research front, scholars have tried to identify the factors that could discourage women from choosing nuclear engineering. A commonly studied factor is gender differences in the perception towards nuclear energy. Studies have shown that women tend to have a greater opposition to nuclear energy compared to men, largely due to concerns about radiation exposure and associated risks during pregnancy, as well as a lack of knowledge and familiarity with the field relative to men [4–7]. These differences may deter women from pursuing a degree in nuclear engineering and a career in nuclear-related fields.

This study aims to contribute to the existing research and policy efforts by examining female representation among faculty in nuclear engineering. Our focus pertains to the findings from research in economics and education that show having a role model has an important effect for historically under-represented populations, including women, to break stereotypes and pursue the corresponding career path. Specifically relating to faculty composition, various studies report evidence suggesting that limited opportunities to meet women in the same field of

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[1] Member countries include Argentina, Australia, Belgium, Canada, France, Hungary, Italy, Japan, South Korea, Norway, Poland, Romania, Russia (NEA membership suspended as of 11 May 2022), Slovenia, Spain, Sweden and the UK. For comparison, in general STEM R&D, women comprise over 30% of the workforce [20].

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work might dissuade women from pursuing their field of interest (see Ref. [8–13]). In fact, this line of studies supports a series of gender-conscious policies and practices promoting female scholarship and gender equality in STEM fields, such as affirmative action in faculty recruitment and promotion, research grant awards and funding programs, and mentoring and training services at the national, local, and institutional levels ([14]; [23]; [15–17]).

As a result, we assess the extent to which nuclear engineering is successful in attracting women to its workforce by comparing its female faculty share with that of other fields across all majors. To do so, we collect college-major level information among four-year Korean colleges from 2000 to 2022. The information includes faculty size, the percentage of female faculty members, as well as the number of degree recipients and gender composition in undergraduate, master's, and doctoral programs for each college-major in a college.

During the sample period, the nuclear engineering major had the third lowest percentage of full-time faculty members who were women at 2.55%, after mechanical engineering (1.63%) and electrical and electronic engineering (1.93%). The share of female faculty members in nuclear engineering increased by 5.08 percentage points from 2000 to 2022, which was the fifth smallest increase among all majors. The majors with smaller increases were physical science (1.99%pts), electrical and electronic engineering (3.40%pts), mechanical engineering (3.43% pts), and arts and athletics (4.24%pts).

However, once we control for various accounting factors using multivariate linear regression models, the nuclear engineering major is comparable to electrical and electronic engineering, mechanical engineering, and physical science in terms of both the overall and time-trend female faculty share. Moreover, contrary to the raw statistics, we find that the nuclear engineering major has an annual increase in female faculty share similar to food and nutrition science and nursing and health sciences, which have high shares of female faculty.

Our findings imply two important policy implications for nuclear engineering. First, assessing whether women are under-represented in a specific field requires careful examinations of compounding factors rather than relying on simple statistics. As shown by our results, nuclear engineering appears to underperform in recruiting female faculty based on simple statistics, but it is comparable to other fields once we control for other factors that could affect female faculty share. Second, to increase female representation in faculty, a field should engage in attracting women at the early stage of their career. We find that a one percentage point increase in female share among bachelor's degree recipients is associated with a 0.127 percentage point increase in female share of full-time faculty members. For nuclear engineering, an increase in the proportion of female bachelor's degree recipients from 20.12% (the average in 2022) to 38.20%, which would align with chemical engineering—the field with the highest proportion of female bachelor's degree recipients among engineering fields—could lead to a rise in the percentage of female faculty from 5.08% (the average in 2022) to 7.38%, representing a 45.28% increase.

The rest of this study is organized as follows: Section II describes the status of female representation in the nuclear field in South Korea. Section III provides the details about the data and empirical framework. Section IV presents the findings, and Section V concludes.

1.1. *Women's representation in nuclear engineering in South Korea*

The first nuclear engineering department was established at Hanyang University in 1958, and currently, there are a total of 17 colleges offering nuclear engineering programs in South Korea.[2] In 2022, nuclear engineering departments had a total of 1521 students enrolled in bachelor's, 320 in master's, 233 in doctoral, and 150 in master's and doctoral joint degree programs. Of these, women accounted for 17.94% of degree program enrollees, with the percentage of female students being 18.21% for bachelor's, 19.06% for master's, 15.45% for doctoral, and 16.67% for master's and doctoral joint programs.

Regarding the overall representation of female faculty, they accounted for 5.53% of faculty positions in nuclear engineering, with 12 out of a total of 217 faculty members in the field being women. This includes 2 out of 76 full professors, 1 out of 33 associate professors, 3 out of 17 assistant professors, 0 out of 2 full-time lecturers, and 6 out of 89 unclassified teaching professionals (Korea Atomic Industrial Forum (KAIF), 2022). The Korean Nuclear Society (KNS) and Women in Nuclear Korea (WiN Korea) offer various programs, such as symposia, training courses, lectures, and mentoring services, to support and empower promising female scholars in nuclear engineering and help them overcome potential challenges that they might face, as reported by Nam [18].

2. Data and summary statistics

2.1. *Data*

Our data is sourced from the Education Statistics available at the Korean Educational Statistics Service (KESS), which is collected and administered by the Korean Educational Development Institute (KEDI). The KESS provides detailed information about students and staff, including their gender, cohort, and enrollment and graduation status, spanning from 2000 to 2022 for each college and major. To narrow our sample, we focus on baccalaureate and above degree-granting colleges that are classified as "University, University of Education, Graduate School, and Professional School" by KEDI. Additionally, we exclude observations that report zero numbers of students and faculty members.

We have classified college majors into 22 groups: 1) nuclear engineering, 2) chemical engineering, 3) civil engineering, 4) computer science, 5) electrical and electronic engineering, 6) industrial engineering, 7) mechanical engineering, 8) other unclassified engineering, 9) agricultural science, including environmental science, 10) biology, 11) chemistry, 12) food and nutrition science, 13) mathematics and statistics, 14) physical science, including astronomy, atmosphere, and

[2] As of 2022, the 17 colleges are Hanyang (1958), Seoul National (1959), Kyunghee (1979), the Korea Advanced Institute of Science and Technology (KAIST, 1980), Chosun (1985), Sejong (2013), Ulsan National Institute of Science and Technology (UNIST, 2009), Jeju National (1990), Uiduk (2006), Dongguk WISE (2008), Kyungpook National (2011), Pusan National (2011), Jeonbuk National (2014), Dangook (2015), Chung-Ang (2013), Pohang University of Science and Technology (POSTECH, 2010), and the Korean Electronic Power Corporation (KEPCO) International Nuclear Graduate School (KINGS, 2012). The launch year of nuclear engineering degree programs is indicated in parentheses. The first seven colleges provide independent degree programs in nuclear engineering, while the subsequent eight offer programs in related fields such as electronic, energy, or mechanical engineering, with a specific focus on nuclear engineering. Despite a comprehensive enumeration of all institutions, some among these eight colleges may not be recognized as institutions offering nuclear engineering majors because the names of the majors do not include the term 'nuclear.' Additionally, some institutions provide statistics based on the overarching major instead of specifically for the nuclear engineering track within a major; consequently, statistics solely for the nuclear engineering track are not available. Lastly, POSTECH and KINGS exclusively offer graduate programs. (Source: [21,22]). Note that, historically, a total of 20 colleges have offered degree programs in nuclear engineering or related fields. However, three colleges, namely Kyungil, Gyeongju, and Inje, have discontinued these programs.

earth science, 15) other unclassified science, 16) nursing and health science, 17) medicine and pharmacy, 18) business and economics, 19) other social science, excluding business and economics, 20) education, 21) humanities, and 22) arts and athletics. This classification is required to ensure comparability across time and observations as some colleges named their majors in non-standard ways and others changed the names of their majors over time.

2.2. Summary statistics and data patterns

We begin by examining the characteristics of colleges that offer nuclear engineering programs in comparison to those that do not. In Table 1, we can see that our sample consists of 248 colleges, with only 16 of them (6.45%) offering nuclear engineering programs (columns (2) and (3), respectively).[3] In the sample, the colleges that offer nuclear engineering programs and those that do not show differences in observable characteristics. The former are more likely to be public and concentrated in Seoul and Gyeongsangbuk-do. To compare college selectivity between those that offer degree programs in nuclear engineering and those that do not, we classify the colleges into three groups based on the Collegiate Scholastic Aptitude Test (CSAT) selectivity scores of incoming bachelor's students in2022.[4] Firstly, the college-wide average CSAT score is calculated, and then decile ranks are determined. Colleges in the top decile are defined as high-selectivity, while those in the second and third deciles are categorized as medium-selectivity, with the remainder classified as low-selectivity. Among the colleges offering nuclear engineering programs, 52.52% are classified as the most selective. Similarly, the colleges that offer nuclear engineering programs have a higher average selectivity than those that do not, suggesting that a simple comparison between nuclear engineering and other majors may result in biased conclusions about the true impact of the nuclear engineering major on female representation if quality differences are not taken into account.

Column (1) of Table 2 displays the mean percentage of full-time female faculty members across years by major in our baseline sample, with weights applied to account for differences in faculty sizes across observations. The major with the third lowest female faculty share is nuclear engineering, at 2.55%. The majors with the lowest female faculty shares are mechanical engineering (1.63%) and electrical and electronic engineering (1.93%). In contrast, nursing and health science (63.15%) and food and nutrition science (45.11%) have the highest female faculty shares. Columns (2) and (3) show the female faculty shares in 2000 and 2022, respectively, which mark the beginning and end of our sample period. Over this time period, the female faculty share in nuclear engineering increased by 5.08 percentage points. The largest and smallest changes in the female faculty share over the period are found in education (23.67 percentage points) and physical science (1.99 percentage points), respectively.

Columns (4)–(12) of Table 2 present the weighted average percentage of female bachelor's, master's, and doctoral degree recipients in each major. Weights are applied using the number of degree recipients to account for differences in program sizes. The three majors with the lowest female share in both full-time faculty members and degree recipients are mechanical engineering, electrical and electronic engineering, and nuclear engineering.

Table 1
Characteristics of the institutions.

	All	Colleges offering nuclear eng. prog.	Colleges without nuclear eng. prog.
	(1)	(2)	(3)
No. observations	248	16	232
(unit: %)			
Public institution	18.95	25.00	18.53
Postgraduate-only institution	18.15	12.50	18.53
CSAT selectivity			
- High-selectivity	10.84	42.86	8.47
- Medium-selectivity	18.23	14.29	18.52
- Low-selectivity	70.94	42.86	73.02
Location			
- Seoul	25.00	18.75	25.43
- Busan	5.65	0.00	6.03
- Incheon	2.42	0.00	2.59
- Daejeon	4.84	12.50	4.31
- Daegu	1.61	0.00	1.72
- Gwangju	4.44	6.25	4.31
- Ulsan	1.21	12.50	0.43
- Sejong	2.02	0.00	2.16
- Gyeonggi-do	18.15	6.25	18.97
- Gangwon-do	4.03	6.25	3.88
- Chungcheongbuk-do	4.84	0.00	5.17
- Chungcheongnam-do	5.65	0.00	6.03
- Gyeongsangbuk-do	7.66	25.00	6.47
- Gyeongsangnam-do	3.63	6.25	3.45
- Jeollabuk-do	4.03	6.25	3.88
- Jeollanam-do	4.03	0.00	4.31
- Jeju-do	0.81	0.00	0.86

Notes: The table reports the characteristics of colleges in our baseline sample in year 2022. Colleges are divided into three CSAT selectivity groups based on test scores of incoming bachelor's students in 2022; The high-selectivity group includes the colleges who belong to the top decile group in terms of the average CSAT scores, the medium-selectivity includes those who belong to the second and third deciles, and low-selectivity group includes the remainder.

3. Statistical analysis

3.1. Methodology

This section lays out a statistical model that allows us to account for compounding factors such as differences in college type, selectivity, location, and female share among degree recipients across colleges and majors. Once we successfully sort out the role of compounding factors, then we can examine the extent to which nuclear engineering as an academic field performs better or worse than other fields. To accomplish this, the study employs a panel regression model:

$$Y_{m,c,t} = \alpha_m + \beta_m t + \mu_c + \sum_k \gamma X^k_{m,c,t} + \varepsilon_{m,c,t} \quad (1)$$

where $Y_{m,c,t}$ is the percentage of female faculty members in major m at

[3] Among the 17 colleges discussed in the previous paragraph, information on the nuclear engineering majors at Uiduk, Kyungpook National, Pusan National, and Chung-Ang is not available from our sample because these colleges do not offer independent degree programs in nuclear engineering and do not provide statistics for those pursuing a degree with a specific focus on nuclear engineering within electronic, energy, or mechanical engineering. Instead, data on the nuclear engineering majors previously offered at Kyungil, Gyeongju, and Inje is accessible. Information on nuclear engineering majors is available until 2021 for Kyungil and Inje, and until 2017 for Gyeongju. Therefore, a total of 16 colleges offer majors in nuclear engineering in our sample.

[4] It is important to note that information on Collegiate Scholastic Aptitude Test (CSAT) scores is not publicly available. Hence, to determine the selectivity of colleges, we use the CSAT cutoff for college admissions provided by Etoos, one of the major private after-school tutoring firms. In cases where this information is missing or unavailable for the year 2022, we estimate the selectivity of colleges using data from other tutoring firms, such as Daesung, Jongro, Uway, and Jinhak, or previous years' CSAT cutoffs. It is worth mentioning that four colleges, namely Tech University of Korea, Korea Institute of Energy Technology, Korea National University of Cultural Heritage, and Korea National Sport University, are excluded from our analysis due to insufficient data on college selectivity.

Table 2
Female share of faculty and degree recipients by major (unit: %).

	Full-time faculty			Bachelor's degree recipients			Master's degree recipients			Doctoral degree recipients		
	All	2000	2022	All	2000	2022	All	2000	2022	All	2000	2022
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
All	20.28	13.77	25.95	50.80	49.05	52.77	49.50	33.27	55.76	33.84	22.07	40.37
College Major												
- Nuclear eng.	2.55	0.00	5.08	18.13	5.56	20.12	15.99	0.00	18.75	7.27	0.00	11.48
- Chemical eng.	3.88	1.51	8.02	30.61	20.16	38.20	30.18	8.15	38.51	15.69	6.25	20.55
- Civil eng.	4.96	1.76	8.22	26.50	23.00	32.81	27.67	17.78	38.57	15.57	10.20	20.91
- Computer sci.	8.17	4.99	10.86	26.28	31.06	32.52	19.92	16.23	23.76	15.95	17.39	15.28
- Electrical and electronic eng.	1.93	0.55	3.95	12.66	9.17	18.31	11.01	2.84	19.11	6.23	1.33	8.01
- Industrial eng.	4.99	1.69	8.76	26.93	27.00	32.60	20.58	6.53	29.73	12.64	0.00	18.69
- Mechanical eng.	1.63	0.07	3.50	8.78	3.90	14.31	9.14	0.96	14.70	5.12	2.76	7.27
- Unclassified, other eng.	7.45	0.83	9.94	27.78	13.68	32.95	24.91	7.81	29.23	16.86	0.00	19.60
- Agricultural sci.	5.47	2.18	9.76	44.47	39.01	47.28	40.97	29.25	51.91	26.41	8.77	38.39
- Biology	13.18	8.81	17.26	52.60	55.31	56.52	53.14	44.78	57.50	38.54	33.33	42.86
- Chemistry	8.57	5.93	11.07	54.89	50.92	58.29	48.10	30.94	49.64	26.57	8.79	31.99
- Food and nutrition sci.	45.11	40.50	45.72	76.98	85.38	72.49	80.91	72.86	75.50	70.72	78.18	63.81
- Math and statistics	12.22	8.30	14.67	55.26	56.60	46.92	48.86	45.31	41.52	33.02	22.45	19.35
- Physical sci.	8.03	8.06	10.05	37.90	36.90	32.35	27.71	20.39	34.46	17.91	15.31	16.59
- Unclassified, other sci.	11.55	7.69	17.78	41.66	–	46.62	12.50	–	–	41.67	–	–
- Nursing and health sci.	63.15	73.41	65.76	80.13	91.62	76.18	82.67	86.49	84.22	82.86	83.15	82.10
- Medicine and pharmacy	19.77	12.14	26.96	38.56	30.07	44.47	39.21	25.81	49.33	31.51	19.46	44.06
- Business and economics	11.13	2.71	19.61	44.54	35.50	51.44	40.15	23.28	47.70	27.17	9.09	44.02
- Other social sci.	25.08	19.12	32.35	57.72	50.46	61.96	59.24	43.34	60.99	42.08	22.32	56.35
- Education	32.71	19.70	43.37	70.02	77.06	67.19	77.95	63.86	81.86	67.20	43.39	75.55
- Humanities	27.35	19.33	34.53	66.58	65.89	66.45	52.97	45.54	56.02	48.77	33.33	56.36
- Arts and athletics	35.45	34.29	38.53	66.60	68.87	65.64	69.87	65.77	70.07	52.59	35.66	57.40

Notes: The table displays the weighted average percentage of women among full-time faculty as well as bachelor's, master's, and doctoral degree recipients by major across the years in our sample ranging from 2000 to 2022. In addition, the weighted average female percentage for 2000 and 2022 are separately reported. The total numbers of observations are 164,526 in our sample period of 2000–2022, 4692 in 2000, and 8422 in 2022.

college c in year t, and $X_{m,c,t}$ is a vector of time-varying variables, such as the number of faculty members and the number of female and male bachelor's, master's, and doctoral degree recipients within a major. Parameter α_m represents major-fixed effects, which reflects the average in female shares across all years for a given major after accounting for other variables, relative to the baseline college major (mechanical engineering). Parameter β_m measures the major-specific linear time trend. Parameter μ_c captures college-fixed effects, which reflects the average in female share across all years and majors in a given college after accounting for other variables, relative to the baseline college. Note that we choose mechanical engineering as the baseline because it exists in almost all colleges during our sample period, although our choice of the baseline major does not affect the implications of our findings. The error term $\varepsilon_{m,c,t}$ captures the unexplained random shock that could be correlated with another shock as long as they occur in the same college (i.e., $E(\varepsilon_{m,c,t}|\varepsilon_{m',c,t''}) \neq 0$ for $m \neq m'$ and $t \neq t''$). Lastly, we apply weights based on the total number of full-time faculty members in each observation.

We are primarily interested in estimating α_m and β_m for all college majors in our research. If the estimate of α_m for the nuclear engineering major is small compared to the estimates for other majors, it suggests that even after accounting for other factors (i.e., $X_{m,c,t}$), the nuclear engineering major struggles to attract women to its faculty compared to majors with higher values of α_m. Similarly, if the estimate of β_m for the nuclear engineering major is positive but small, it implies that the nuclear engineering major is making slow progress in recruiting women to its faculty compared to majors with larger positive values of β_m.

3.2. Results

The main findings are presented in columns (1) and (2) of Table 3. We use mechanical engineering as a baseline, and all reported estimates for other college majors are relative to mechanical engineering. The estimated value of α_m for nuclear engineering is -1.637, and for chemical engineering, it is -2.186. These results indicate that, compared to mechanical engineering, the female faculty share is 1.637 percentage points lower in nuclear engineering and 2.186 percentage points lower in chemical engineering, even after controlling for other factors that could impact the female faculty share. The difference between mechanical engineering and nuclear engineering (i.e., -1.637) is not statistically significant at the 10% level, while the difference between mechanical engineering and chemical engineering (i.e., -2.186) is statistically significant at the 1% level. This indicates that, given the size of the faculty, undergraduate and graduate programs, and female shares among students, nuclear engineering departments have, on average, the same female faculty share as mechanical engineering departments. However, all else being equal, chemical engineering departments tend to have a smaller share of female faculty than mechanical engineering departments, and this difference is statistically significant at the 1% level.

As for major-specific time trends, we find that the estimated β_m is -0.022 for mechanical engineering and -0.122 for nuclear engineering, and both estimates are not statistically significant from zero at a 10% significance level. This suggests that, conditional on the size of the faculty, undergraduate and graduate programs, and their female shares among students, the share of female faculty in mechanical engineering departments decreases by 2.2 percentage points per year on average, but this trend is not statistically significant. Similarly, holding other factors constant, each year, the female faculty share in nuclear engineering departments decreases by an additional 12.2 percentage points compared to mechanical engineering departments (i.e., a total decrease of 14.4 percentage points per year, obtained by adding -0.122 to -0.022), but this difference is not statistically significant at a 10% significance level. That is, nuclear engineering departments share the same time trend with mechanical engineering departments.

We have categorized majors into six groups based on the signs and statistical significance of our estimated values α_m and β_m (i.e., $\widehat{\alpha}_m$ and

Table 3
Results: Major-specific trends over time in the proportion of female faculty members.

	With all degree recipients				With bachelor's degree recipients only			
	$\widehat{\alpha}_m$		$\widehat{\beta}_m$		$\widehat{\alpha}_m$		$\widehat{\beta}_m$	
	(1)		(2)		(3)		(4)	
Field								
(Ref. = Mechanical eng.)	–	–	−0.022	(0.030)	–	–	−0.013	(0.029)
- Nuclear eng.	−1.637	(3.228)	−0.122	(0.163)	−1.501	(3.270)	−0.086	(0.165)
- Chemical eng.	−2.186***	(0.832)	0.068	(0.052)	−2.121***	(0.799)	0.099*	(0.052)
- Civil eng.	−2.936***	(0.733)	0.170***	(0.034)	−2.554***	(0.699)	0.188***	(0.034)
- Computer sci.	−1.141	(0.820)	0.206***	(0.040)	−0.699	(0.783)	0.207***	(0.039)
- Electrical and electronic eng.	−0.688	(0.829)	0.037	(0.046)	−0.493	(0.765)	0.023	(0.042)
- Industrial eng.	−4.106***	(0.940)	0.241***	(0.061)	−3.926***	(0.917)	0.277***	(0.063)
- Unclassified, other eng.	−2.437	(2.006)	0.251**	(0.119)	−1.864	(1.940)	0.256**	(0.117)
- Agricultural sci.	−1.800*	(1.007)	0.188***	(0.054)	−1.537	(0.988)	0.218***	(0.054)
- Biology	1.507	(1.067)	0.249***	(0.065)	2.120**	(1.039)	0.284***	(0.065)
- Chemistry	−3.149**	(1.350)	0.148**	(0.073)	−2.043	(1.299)	0.165**	(0.072)
- Food and nutrition sci.	29.754***	(3.366)	0.123	(0.170)	31.533***	(3.485)	0.121	(0.175)
- Math and statistics	−0.927	(1.298)	0.306***	(0.073)	−0.234	(1.275)	0.318***	(0.072)
- Physical sci.	1.116	(1.224)	0.068	(0.068)	1.357	(1.188)	0.095	(0.068)
- Unclassified, other sci.	3.135	(2.298)	0.475**	(0.219)	3.721	(2.310)	0.445**	(0.221)
- Nursing and health sci.	50.047***	(3.572)	−0.084	(0.155)	51.652***	(3.748)	−0.076	(0.159)
- Medicine and pharmacy	4.872***	(0.988)	0.583***	(0.035)	4.736***	(0.970)	0.675***	(0.034)
- Business and economics	−5.535***	(0.806)	0.661***	(0.039)	−4.885***	(0.767)	0.702***	(0.038)
- Other social sci.	8.180***	(1.408)	0.501***	(0.072)	8.825***	(1.384)	0.540***	(0.071)
- Education	10.961***	(1.408)	0.971***	(0.066)	11.458***	(1.407)	1.007***	(0.067)
- Humanities	6.983***	(1.000)	0.757***	(0.040)	7.981***	(0.957)	0.762***	(0.039)
- Arts and athletics	20.927***	(1.333)	0.178***	(0.064)	21.763***	(1.322)	0.179***	(0.064)
R^2	0.443				0.438			
$\overline{y}_{m,c,t}$	20.28							
N	164,526							

Notes: The table displays coefficient estimates of weighted regression, with standard errors clustered at the major by institution level in parentheses. Other controls include the number of faculty members, the number and female share of bachelor', master's, and doctoral degree recipients within a major, a full set of dummies for institution, and a full set of year dummies. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

$\widehat{\beta}_m$) at the 10% level. These categories include: (1) both $\widehat{\alpha}_m$ and $\widehat{\beta}_m$ are statistically indifferent from zero, (2) both $\widehat{\alpha}_m$ and $\widehat{\beta}_m$ are positive, (3) $\widehat{\alpha}_m$ is negative and $\widehat{\beta}_m$ is positive, (4) $\widehat{\alpha}_m$ is positive and $\widehat{\beta}_m$ is not statistically different from zero, (5) $\widehat{\alpha}_m$ is negative and $\widehat{\beta}_m$ is not statistically different from zero, and (6) $\widehat{\alpha}_m$ is not statistically different from zero and $\widehat{\beta}_m$ is positive. In Fig. 1, the x-axis and y-axis represent the signs and magnitudes of $\widehat{\alpha}_m$ and $\widehat{\beta}_m$, respectively.

At the coordinate (0,0) on the graph, we place four college majors that belong to group (1), including mechanical engineering (the baseline), nuclear engineering, electrical and electronic engineering, and physical science. These college majors exhibit similar performance to mechanical engineering in terms of both the overall and time-trend female faculty shares. The college majors belonging to group (2) can be regarded as those that surpass nuclear engineering majors in terms of the overall and time-trend female faculty shares, as they have significantly positive $\widehat{\alpha}_m$ and $\widehat{\beta}_m$.

In the upper left quadrant of the graph, we can find the college majors belonging to group (3), which have negative $\widehat{\alpha}_m$ and positive $\widehat{\beta}_m$ at a 10% significance level. These majors include chemistry, civil engineering, agricultural science, industrial engineering, and business and economics. They perform better than nuclear engineering majors in terms of the time trend, that is, how fast the share of female faculty increases over time, but not in the overall level when considering the share of female students among all students.

The remaining three groups (groups (4) to (6)) are comparable to nuclear engineering in terms of either $\widehat{\alpha}_m$ or $\widehat{\beta}_m$, but not both. For instance, in terms of the time trend, nuclear engineering shows a similar annual increase in the female faculty share as that of food and nutrition science and nursing and health sciences, which have high shares of female faculty in our sample (45.11%, and 63.15%, respectively).

In summary, in terms of securing women in faculty positions, nuclear engineering majors perform strictly worse than five college majors in group (2)– namely, arts and athletics, education, humanities, medicine and pharmacy, and other social sciences. However, nuclear engineering performs no worse than the rest of the college majors considering various compounding factors that could affect female faculty share.

Finally, Table 4 presents the estimates for the female share and number of bachelor's, master's, and doctoral degree recipients as well as full-time faculty members. Column (1) demonstrates that a 1 percentage point increase in the female share among bachelor's, master's, and doctoral degree recipients corresponds to an increase in the female faculty share of approximately 0.127, 0.052, and 0.021 percentage points, respectively. From 2000 to 2022, the female shares among students increased by 3.72 percentage points for undergraduates, 22.49 percentage points for master's degree recipients, and 18.30 percentage points for PhD holders, respectively (see Table 2). Multiplying these numbers with the corresponding estimates and adding them up results in a 2.03 percentage point increase. That means that 2.03 percentage points out of the total increase in the female faculty share (i.e., 5.08 percentage points) are attributable to the increased share of female students among all students at all levels of degree programs, which accounts for 39.89 percent. Finally, we find a negative association between the size of the student body and female faculty share, but a positive association between the number of total faculty members and female faculty share.

As a robustness check, we run the regression model again while excluding the variables for female share and number of master's and doctoral degree recipients. This is because, in certain fields, pursuing a graduate degree abroad is considered crucial for in-depth learning and a smoother transition to work post-graduation. Consequently, the female share and the number of master's and doctoral degree recipients from domestic colleges may not accurately reflect the number of bachelor's degree recipients who pursue graduate studies abroad. To address this limitation, we used an alternative approach to assess the extent to which our results are sensitive to this data constraint. We estimated the female faculty share based solely on information from undergraduates,

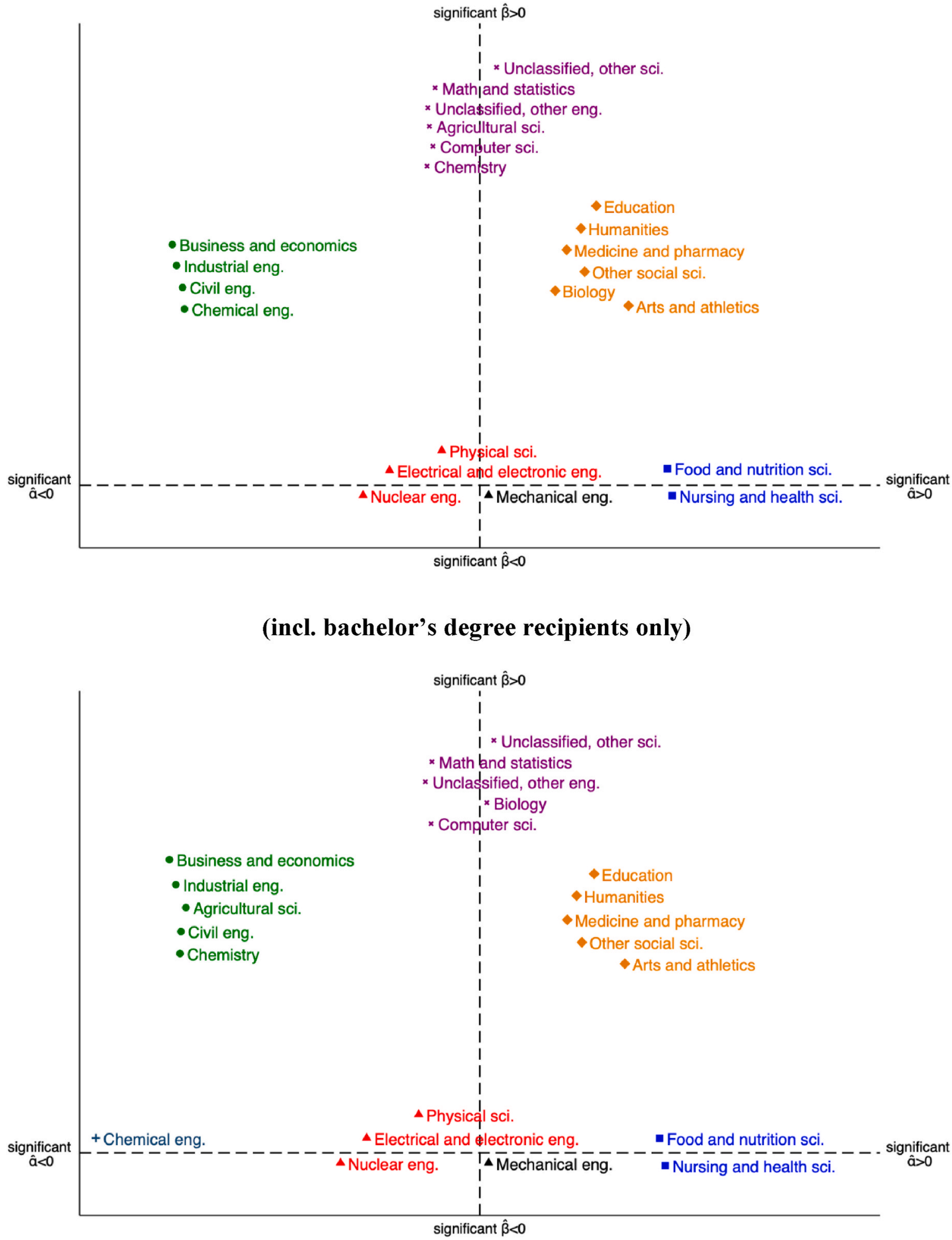

Fig. 1. Trends in female faculty share by major.

excluding the number of master's and doctoral degree recipients. While this alternative specification may diminish the predictive power of the estimation results by omitting relevant explanatory variables, it helps avoid potential biases arising from the systematic exclusion of the number of degree holders from abroad. This alternative approach allows us to compare the results with our baseline findings and analyze the impact of limited information on degree recipients from abroad. The results, presented in columns (3) and (4) of Table 3 and column (2) of Table 4, show no significant changes in the outcomes. All coefficients exhibit the same sign and similar magnitudes. The only difference is found in the significance of estimates for agricultural science, chemistry, biology, and chemical engineering, which might be significantly influenced by the number of master's and doctoral degree recipients from abroad. These findings from the alternative approach provide evidence supporting the validity of our results.

Table 4
Results: Observable characteristics and proportion of female faculty members.

	With all degree recipients		With bachelor's degree recipients only	
	(1)		(2)	
Female share of degree recipients				
- bachelor's	0.127***	(0.007)	0.140***	(0.007)
- master's	0.052***	(0.005)	–	–
- doctoral	0.021***	(0.007)	–	–
Number of degree recipients				
- bachelor's	−0.017***	(0.003)	−0.018***	(0.003)
- master's	−0.010	(0.009)	–	–
- doctoral	−0.085***	(0.020)	–	–
Number of full-time faculty members	0.008***	(0.003)	0.001	(0.003)
R^2	0.443		0.438	
$\overline{y}_{m,c,t}$	20.28			
N	164,526			

Notes: The table displays coefficient estimates of weighted regression, with standard errors clustered at the major by institution level in parentheses. Other controls include a full set of dummies for institution, and a full set of year dummies, and a full set of institution-specific linear time trends. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

4. Conclusion

In this study, we construct a novel dataset that includes panel information for every college major at all Korean universities from 2000 to 2022. The objective is to gauge the success of nuclear engineering in attracting female faculty in comparison to other majors. The study adopts a quantitative approach, and unlike a basic statistical analysis that places the nuclear engineering major third from the bottom in terms of the share of female faculty, our findings demonstrate that it performs comparably to other fields when controlling for the major-specific number and gender composition of degree recipients and college fixed effects.

Our study emphasizes the need for thorough and rigorous quantitative analysis when measuring gender gaps and developing policies to address them. In this regard, our findings raise some concerns regarding a recent gender-related policy implemented in Korea. In January 2020, the [19] Official Act was amended to set a minimum yearly target for the female faculty share in all public colleges, starting from 19.8% in 2023 and reaching 25.0% by 2030. Given that the share of female faculty is only 5.08% in 2022, nuclear engineering majors should actively recruit female faculty to comply with this new policy. However, no study has provided clear statistical evidence suggesting that public colleges are less female faculty-friendly than private colleges in their hiring practices. Conversely, the policy goal seems to be based on the observation that the overall female faculty share in public colleges (17.70% in 2020) is lower than that of private colleges (27.06% in 2020). This gap could be attributed to gender-biased hiring practices in public colleges, but it could also be influenced by other observable differences, as public colleges in Korea tend to have larger engineering schools than private colleges. In the context of nuclear engineering, the female faculty share at public colleges (3.13%) is 2.68 percentage points lower than that at private colleges (5.81%). However, this difference does not necessarily imply that public colleges underperform compared to private colleges under a similar interpretation of our main findings. Without identifying the underlying factors hindering women's status, such a policy may not achieve its ultimate goal. Instead, our findings highlight the importance of attracting female students at all degree levels. This suggests that policymakers might be better off promoting female representation in STEM fields, including nuclear engineering, early on, rather than focusing on achieving a specific share of women among faculty.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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