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GENDER PARITY AMONG RESEARCHERS IN SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS

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Abstract. This study compares women's disparity in science over a period of 5 years (2013–2017) in eight continental regions of the world using synthesised data from a UNESCO scientific report with a desktop literature review and deductive inference from statistical analysis. The different descriptive measures, such as mean percentages, correlations, multifactor analysis (MFA), and non-linear regression, identify the trend, change points, factors, and best-fit exponential time series for decision-making. We determined that each continent follows the same exponential smoothing trend, with a correlation coefficient of 0.67, over the years of study and that the year of study exhibits a different exponential trend that varies over the different continental regions' counterparts. The study also highlights gender bias, family life, mentoring, and stereotypes as significant factors contributing to the relationship between science and gender parity. Therefore, this study advocates policy implementation of science, technology, engineering, and mathematics (STEM) to ensure women's representation in scientific research.

Keywords: Gender parity; STEM; Women in science; Research

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Additional disciplines: Science and technology

1. Introduction

The underrepresentation of women and girls in the science, technology, engineering, and mathematics (STEM) sectors is a global concern (Cheryan, Ziegler, Montoya & Jiang, 2017). Currently, the world is witnessing a leaky pipeline regarding women's engagement in research. Extant research suggests that women actively seek bachelor's and master's degrees and even outnumber men at these levels, accounting for 53% of graduates, but their numbers decrease precipitously at the doctoral level. Furthermore, men account for 72% of the global pool of researchers, widening the gender gap even further. As a result, the high number of women in tertiary education does not always imply a greater representation in research (Huyer, 2015). Between 2011 and 2013, the percentage of female researchers increased in South Africa (437%), Egypt (428%), Morocco (302%), Senegal (249%), Nigeria (233%), Rwanda (218%), Cameroon (218%), and Ethiopia (133%). However, a decline in women advancing along the scientific research career path has been observed. Thus, gender gaps in the scientific workforce continue to exist (Bezrukova, Spell, Perry & Jehn, 2016; Cech & Blair-Loy, 2010).

Another school of thought suggests that even though women constitute only 28% of global researchers, this figure masks significant differences at national and regional levels based on current data. For instance, women are overrepresented in Southeast Europe (49%) and the Caribbean, Central Asia, and Latin America (44%). One in every three researchers in the Arab States (37%) is a woman, followed by the European Free Trade Association (34%), the European Union (33%), and Sub-Saharan Africa (30%) (Huyer, 2015). According to UNESCO (2015), women now account for 53% of all bachelor's and master's degree holders in STEM, though only 30% of all researchers. Women leave the field at a higher rate than men, indicating a waste of social investment, individual effort, and systemic issues with maintaining women in STEM careers. Although women have reached parity in the life sciences in many nations, they are chronically underrepresented in engineering and computer science (Sirimanne, 2019). For instance, women in the European Union graduated primarily in health and welfare, humanities and the arts, social sciences, business, and law in 2014. In contrast, men are more likely to have degrees in engineering, manufacturing, and construction, followed by technology, science, and math. Despite an increase in the overall number of STEM students between 2003 and 2013, the gender gap remains the same (European Institute for Gender Equality, 2017).

Despite the rising acknowledgement of the significance of this issue in developing nations, most of the literature on gender inequality in STEM and the policies to address it has been centred on the United States and Europe. Not only are women underrepresented in STEM disciplines in developing nations, but they are also under-measured, and a lack of data has hampered academics from gaining a better understanding of the reasons for this disparity (Castillo, Grazzi & Tacsir, 2014). Other variables that may contribute to women's difficulty in advancing in scientific and technological fields include the presence of stereotypes, which may limit their ability to secure a better job or research funding (Suter, 2006). Furthermore, according to UNESCO (2007), taking time off work while her children are young may impact a woman's professional advancement. Consequently, it is difficult to return to a position equal to those who have not taken time off and gradually advanced in their jobs. This is especially true in scientific research, where publishing is a critical growth component. According to Dasgupta (2017), there is a naturally growing demand for scientists, engineers, and mathematicians (STEM). However, women, who account for more than half of the world's population, are underrepresented in these fields. Men continue to dominate in many countries' STEM workforces. In 2016, women constituted less than one third (29.3%) of individuals working globally in scientific research and development. The only locations where women formed more than one-third of the R&D workforce were Central Asia (48.2%), Latin America and the Caribbean (45.1%), the Arab States (41.5%), and Central and Eastern Europe (39.5%) (UNESCO Institute for Statistics, 2019). Therefore, this study provides a comparative analysis of regional and continental gender parity among researchers in science.

2. Literature review

2.1 Disparities in STEM education between women and men

Science and gender equality are critical to the world's ability to achieve long-term development goals. Moreover, much has been carried out to encourage women and girls to study and work in technical disciplines in recent years; however, women are still barred from actively engaging in them (Wood, 2020). Gender disparities in STEM are visible in terms of representation (especially in the high-level roles and subfields of computer science and engineering), remuneration, and, to a lesser extent, grants, publications, and awards. The weight of evidence no longer supports the notion that fundamental differences in ability cause these inequalities. Instead, gender disparities in STEM appear to be partly caused by variations in perceived values and opportunities in related contexts and ubiquitous implicit and explicit prejudices that impact these beliefs (Charlesworth & Banaji, 2019). Persistent gender inequality severely restricts women's ability to reach their full potential and contribute effectively to development. Furthermore, women scientists are frequently concentrated in the lower tiers of responsibility and decision-making, with few prospects for leadership; for example, lecturers and assistant researchers in universities, with very few professors. Women are rarely research directors or primary investigators in extensive studies at research institutions (African Academy of Sciences, 2020). Researchers studying discrimination have distinguished between aggressive and benign forms of sexism, with both involving attitudes that men should be dominant over women. However, while aggressive forms include disparaging and exploitative views and behaviours against women, benign forms include affectionate views of and behaviours towards women (e.g., the roles of men as the provider and protector and women as the nurturer). Both forms of sexism operate to keep women out of power and to maintain patriarchy in place; however, benign forms of sexism are frequently dismissed as types of sexism and may not even be viewed as harmful to women (Wang & Degol, 2017).

2.2 Factors that contribute to women's underrepresentation in the sciences

Several variables contribute to the disproportionate participation of women in STEM, including social and psychological considerations. To comprehend women's experiences in the workplace, the "glass ceiling" metaphor has been used to characterise the barriers to women's professional advancement (Morrison et al., 1987). The number of women in the STEM academic pipeline has decreased. Women face several challenges as they rise up the educational ladder in research and teaching. Several factors contribute to this problem, some of which may be more relevant in particular regions of the world. Overall, women have difficulty remaining in their employment positions and progressing in their careers. These problems are coupled with a lack of clearly defined institutional regulations governing advancement, access to resources, and job training. Other factors prevalent all around the globe that make it difficult for women to progress in their participation include a lack of networking, mentoring, and leadership coaching (Cummings, 2015). Women working in technological areas face several obstacles that prohibit them from starting or succeeding in their careers. The following factors were identified as significant impediments in a recent global survey of women working in technology: 48% of the respondents reported a shortage of mentors during their professional careers; 42% believed that there were insufficient female role models; gender bias in the workplace was experienced by 39%; in comparison to men, 36% believed that they had unequal prospects for advancement; and there was a gender wage discrepancy for the same skills, according to 35% of the respondents (Heilman, 1995).

2.2.1 Gender bias

Women in STEM fields are more likely to report gender discrimination in the workplace than men. Half (50%) of women in STEM careers report experiencing workplace discrimination due to their gender being higher than women in non-STEM jobs (41%) and significantly more than males in STEM occupations (19%). The most common forms of gender discrimination experienced by women in STEM jobs include earning less than a man doing the same job (29%); being treated as incompetent (29%); experiencing repeated, minor insults in the workplace (20%); and receiving less support from senior leaders than a man doing the same job (18%) (Funk & Parker, 2018). Similar barriers to women's access and advancement have been reported for industrial research jobs, such as limited access to industrial jobs in science and engineering, the "old boys network" effect in recruitment and hiring practices, paternalism, sexual harassment, allegations of reverse discrimination, different standards for judging men's and women's work, lower salaries relative to male peers, inequitable job assignments, and other aspects of a male-oriented culture (Etzkowitzi & Ranga, 2011). This view has been reinforced by Wood (2020), who observed that women who choose to accept the challenge and pursue a STEM job might face unequal remuneration and limited future career advancement.

Gender balance in the workplace is essential for women in non-STEM positions as well, but those in STEM jobs noticeably encounter workplace discrimination. There is a feeling that they need to prove themselves in order to be respected by co-workers, accompanied by their belief that, overall, their gender has made it more difficult for them to succeed at work. In contrast, gender balance in the workplace has generally been linked to opinions on gender parity (Funk & Parker, 2018). Makarova, Aeschlimann and Herzog (2016) argued that it is challenging for young women to integrate within a male-dominated professional setting. They must be highly resilient in the face of gender-biased sentiments. At the same time, they must identify their place, submit themselves to predominantly masculine workplace culture, demonstrate strong performance dedication, and avoid uncomfortable situations. Oliveira, Unbehaum and Gava (2019) averred that there is a need to take steps to ensure that women have an equal voice in all aspects of social, economic, and political life, including the creation and advancement of new scientific and technological developments and innovations. In this instance, for gender equality, equal participation can only be achieved by removing the barriers preventing some individuals from engaging as equals.

2.2.2 Family life

The absence of gender-sensitive policy frameworks, such as on-site childcare or career re-entry programmes to encourage women scientists to return to science after taking leave to start a family, contributes to women scientists abandoning the science profession, thereby enlarging the gender divide in health research. This is exacerbated by the lack of gender-sensitive promotion mechanisms to ensure women's professional development. Not only can these approaches discourage individuals from pursuing long-term careers in research, but they also often result in women leaving the profession to pursue other interests (Muthumbi & Sommerfeld, 2015). According to the human capital theory, women are disadvantaged in the sciences due to a lack of human capital resources. This is manifested as a decreased level of competence and abilities due to employment interruptions, such as family leaves. Over time, their knowledge and professional experience become outdated or are lost, but their male colleagues increase their productivity. As a result, when women return to work, they will not pursue the same professional path as males (such as a permanent employment contract, tenure track, or the prospects for commercialising their knowledge). The human capital theory assumes that human capital resources are based on individual choices made by employees in the past (for women, this involves the decision to give birth to and raise a child). Because of these decisions, women are less likely to be promoted to science positions (Polkowska, 2013).

When women decide to have children, the overlap between their optimal years of fertility and tenure pursuits causes many to regard STEM fields, or tenure-track academic employment in general, as unsuitable for accomplishing their familial goals (Williams & Ceci, 2012). Many women who work in research must combine their careers with caring for their children. Having a solid support structure from their family has been critical for many women. Teaching partners and families to be more supportive and participative would be a major benefit, as would emphasising the engagement and involvement of males in taking on family obligations, which would help promote a structural and societal shift (Tiedeu, Para-Mallam & Nyambi, 2019). Another school of thought suggests that family obligations and departments' work-life policies have a more significant impact on female faculty satisfaction than male faculty members, given that women care for young children and the elderly at a higher rate than males. The difficulty of balancing caregiving with work responsibilities is exacerbated by the fact that most colleges do not offer child care. Women's travel to conferences, where colleagues outside their home university might learn about their work, is restricted by caregiving duties. Absence from the conference and invited lecture circuit, on the other hand, makes it more challenging to achieve the worldwide reputation essential for promotion to full professor. According to recent retention research, women are more likely to cite family-related difficulties and a lack of time as reasons for quitting STEM jobs than males (Frehill, Di Fabio, Hill, Trager & Buono, 2008).

2.2.3 Mentoring

The availability of role models and mentors impacts the achievement of professional development. Young adults identify with successful female role models whose presence inspires them to believe that "if she can be successful, so can I," and "I want to be like her." On the other hand, female college students are more likely to encounter few same-sex role models who work in STEM departments because STEM faculty members are four times more likely to be men than women, particularly in full physical sciences and engineering (National Science Foundation [NSF], 2013). Therefore, academic departments should seek out senior women in STEM to present their technical work at department colloquia, brown-bag luncheons, and other special events, allowing these speakers to meet and mentor students. The Computing Research Association, for example, sponsors the Distributed Lecture Series, which brings female teachers and technical researchers from businesses to university campuses to serve as female role models (Dasgupta & Stout, 2014). Thus, young women with successful female STEM professionals (such as scientists, engineers, mathematicians, and computer scientists) foster a proper understanding of STEM fields and access to female role models. Contact with STEM workers could begin in primary school and continue throughout schooling and early career development (Marginson, Tytler, Freeman & Roberts, 2013).

There is a need to combine efforts and interventions, such as mentorship projects, outreach activities, and professional development programmes to break prejudices regarding who can do STEM and what can be accomplished with STEM studies (Kigotho, 2021). Aside from inspiring others, role models may also function as mentors. Thus, they provide the growth, promotion, and broadening of students' perspectives and build a network of like-minded professionals. The lack of female role models makes it more difficult for women in their initial years of college to understand how to navigate the road to a job in STEM, which necessitates the formation of social capital (Dasgupta & Stout, 2014). Mentoring is critical in increasing and retaining women in scientific and technical jobs. Mentoring addresses stereotypical conceptions of STEM occupations as inflexible or male-dominated, preventing many girls from engaging in STEM disciplines by connecting existing role models with nascent STEM professionals. Furthermore, increasing the representation of women and girls in scientific and technological disciplines is a global necessity. The potential for advancement is excellent as STEM skills become increasingly vital in a globally networked economy (Executive Office of the President of the United States of America, 2013). University and research organisations must make STEM occupations more appealing to women, and tackling the current causes of underrepresentation necessitates reforms in policies and teaching techniques. A lack of inspiring role models, work cultures that do not provide enough support, and the perception of the information and communications technology (ICT) working environment as male-dominated and aggressive (in terms of self-confidence) are all viewed as barriers to women entering the field (Su, Rounds & Armstrong, 2009).

2.2.4 Stereotypes

Stereotypes pervade society and can impact opinions concerning an individual's strengths and weaknesses, even when evidence of their skill level suggests otherwise. These ideas can impact how people think, act, and feel about their skills and how they perceive others (Wang & Degol, 2016). Stereotypes hamper the test performance of ability-stigmatised groups, and they fail to reach their full potential. This is an essential channel for explaining why girls perform worse in mathematics when they are assigned to more biased teachers, but it is also broadly relevant because it suggests that exposure to gender stereotypes is at least partially responsible for women's lower self-confidence in scientific fields. Implicit preconceptions produce a self-fulfilling prophecy that perpetuates gender inequalities in mathematics performance (Carlana, 2019). The continuance of horizontal gender segregation in educational and vocational domains adds significantly to the development of gender-stereotypic notions regarding women's natural fit in more expressive and human-centred fields and that of males in technical and math-intensive fields (Charles & Bradley, 2009). Implicit gender-science stereotypes exist throughout the lifespan of both men and women in every society and throughout history. Such persistence and prevalence in unconscious biases are consistent with gender gaps in STEM representation, income, and recognition (Charlesworth & Banaji, 2019).

Change is unlikely unless individuals acknowledge that stereotypes are the basis of gender disparities in society and seek to identify and fix their own prejudices (Ellmers, 2018). Gender bias and stereotypes begin at a young age, with young girls growing up in an environment with few female scientists in the public spotlight. This type of imbalance provides a clear signal to girls at a young age that they do not match the stereotypical mould of a scientist, and, as a result, girls lose confidence in their STEM ability at an early age. When choosing a discipline for university is concerned, it is unsurprising that young women are disinclined to pursue STEM careers (Australian Government, 2019). Women are stereotypically assigned communal attributes such as warmth and caring, whilst males are stereotypically assigned agentic traits, such as competence and assertiveness, with the latter being far more congruent with competitive STEM areas (Settles et al., 2016). Conversely, McKinnon and O'Connell (2020) noted that the top three stereotype categories for women in science who publicly express their work are that they are "bitchy," have a lack of "credibility," and are assessed on their "appearance," with the stereotypical terms being "bossy,” "bitchy,” "emotional," and "motherly."

3. Research methodology

To date, women's inclusion in STEM has only been descriptive or intuitively differentiated. An intercontinental survey has not been explored to find gender disparity evidence in formative research. This study provides a comparative framework using the UNESCO scientific report from 2013 to 2017 by exploring the global percentage of women in STEM in relation to other continentally documented percentages of women (UNESCO Institute for Statistics, 2015-2020). It ranks the formation of either the high or low percentages. A validity pre-test of the collected data was conducted to detect irrelevant ambiguous, and redundant values. This test includes normality and probability tests to study the data distribution consisting of the mean and standard deviation of all the different continents and years in the dataset. Thereafter, differencing was performed. Differencing shows one way to make a non-stationary time series stationary, and it computes the differences between consecutive observations. This data transformation technique helps stabilise the mean and variance of a time series. It removes changes in a time series level and, therefore, eliminates (or reduces) trends and seasonality (Cochrane, 2018). Statistical tools are not limited to analysing trends for change-point analysis in different continents. Therefore, yearly time-series variation was used to ascertain the degree of severance, whether low or high, for each continent, while multiple factor analysis (MFA) was used to uncover the latent structure (dimensions) in assessing the variables. Its principal component analysis reduces the attribute space from a larger number of variables to a smaller number of factors. Principal component analysis (PCA) as a choice of factor analysis (FA) explains the contribution of the unobserved common features in a target event from the observed ones. Purposely, it reduces the variety of collected data matrices to form a few selected derived component variables, which form a true representation of the original sets.

The Kaiser–Meyer–Olkin (KMO) test was used to abstract the factor analysis; this test measures the strength of the relationship among the variables. The KMO test determines whether the responses given with the sample are adequate; the result from this test should be 0.5 or more for satisfactory factor analysis to proceed (Tabachnick & Fidell, 2007). Correlation is another indication of the strength of the relationship among the subject variables. Correlations are useful for indicating a predictive relationship that can be exploited in practice. The correlation matrix is an identity matrix. Therefore, the result from this test should be 0.05 or less for satisfactory factor analysis to proceed (Mukaka, 2012). A correlation was used as part of the inferential statistics analyses to test the relationship between factors that influence each continent and the years considered, while regression analyses were used to determine if there was any relationship between the determining factor and other independent variables that explained the relationship. The goal of logistic regression is to correctly predict the category of output for individual cases using the most parsimonious model (Machira & Palamuleni, 2017). Logistic regression calculates the probability of success over the probability of failure, and the result of the analysis is in the form of an odds ratio. One can compute the slope and intercept for different equations by minimising an asymmetrically weighted sum of absolute errors. In this way, one can obtain information about the presence of non-linear trends for other data distribution levels. The significance of the slope is computed using bootstrapping to highlight its effective significance level α equal to 5% in women participation value.

The coefficient of correlation (CC) and root mean square error (RMSE) are the most frequently used for performance evaluation measures for actual and predicted values. The CC is expressed as in Equation 1:

$$CC = \frac{\sum_{i=1}^{n}\left[\left(Q_i - \hat{Q}_i\right).\left(P_i - \hat{P}_i\right)\right]}{\sqrt{\sum_{i=1}^{n}\left(Q_i - \hat{Q}_i\right)^2 . \sum_{i=1}^{n}\left(P_i - \hat{P}_i\right)^2}} , \qquad (1)$$

where *Qi* is the observed value at time *i*, *Pi* is the simulated value at time *I*, and is the mean for the observed values.

4. Results and discussion

Tables 1 and 2 summarise the pre-data-analysis results for different continental regions and years.

Table 1. Summary of the continental regions

Continent	*Sum*	*Average*	*Variance*
1. Arab States	195.900	39.180	5.047
2. Central and Eastern Europe	197.300	39.460	0.113
3. Central Asia	239.100	47.820	0.397
4. East Asia and the Pacific	117.800	23.560	0.893
5. Latin America and the Caribbean	225.300	45.060	0.343
6. North America and Western Europe	162.100	32.420	0.137
7. South and Western Asia	98.000	19.600	3.880
8. Sub-Saharan Africa	154.600	30.920	0.517

Table 2. Summary by year

Year	*Sum*	*Average*	*Variance*
2013	271.600	33.950	99.757
2014	272.800	34.100	98.894
2015	278.400	34.800	107.357
2016	281.000	35.125	106.836
2017	286.300	35.788	86.567

Likewise, the availability of average and variance distributions (Table 3) of the continental summary over 5 years for the data analysis of the distribution of women in research helps depict the level of the relationship between each continent and the measured years.

Table 3. Kolmogorov–Smirnov test

D	0.444
p-value (two-tailed)	< 0.0001
alpha	0.05

The null assumption (H0) is that the sample follows a normal distribution, but as the computed p-value is lower than the significance level of alpha=0.05, we concluded that the sample does not follow a normal distribution. The pictorial representations of women in science on various continents are depicted in Figures 1 and 2. The pie charts include the descriptions of the study regions for the years 2013 and 2017. One of the continents (South and Western Asia) has average women deviations of 19.8 and 3.5, implying that 2 out of 10 STEM women are employed.

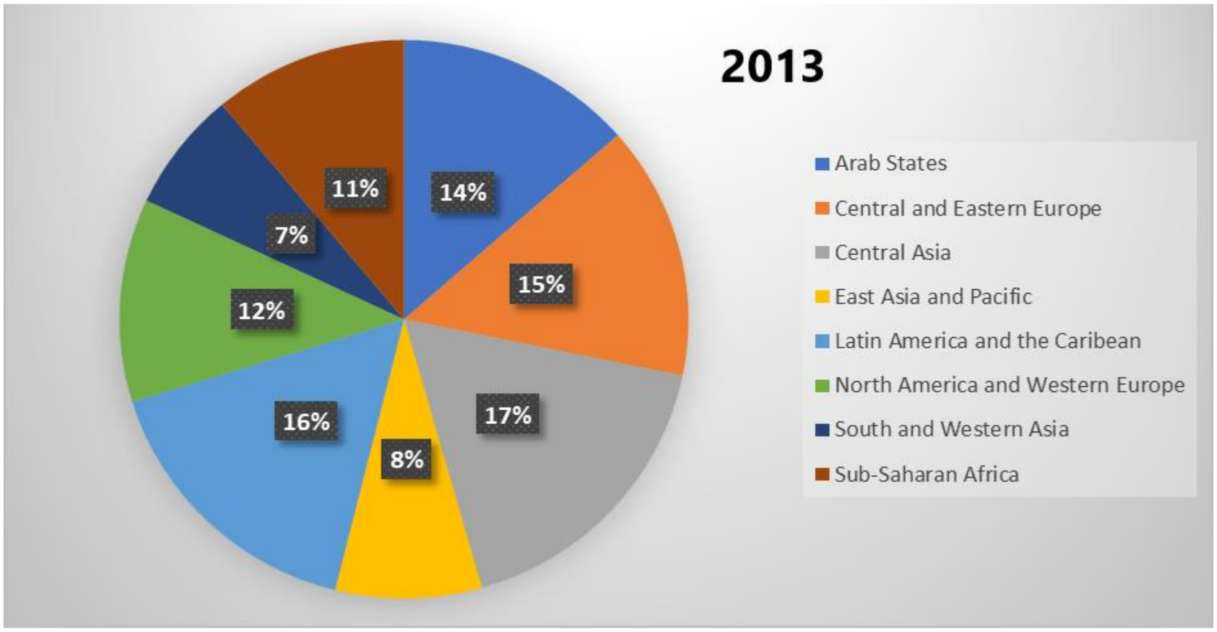


Figure 1. Pictorial representation of women in science in various continental regions for 2013

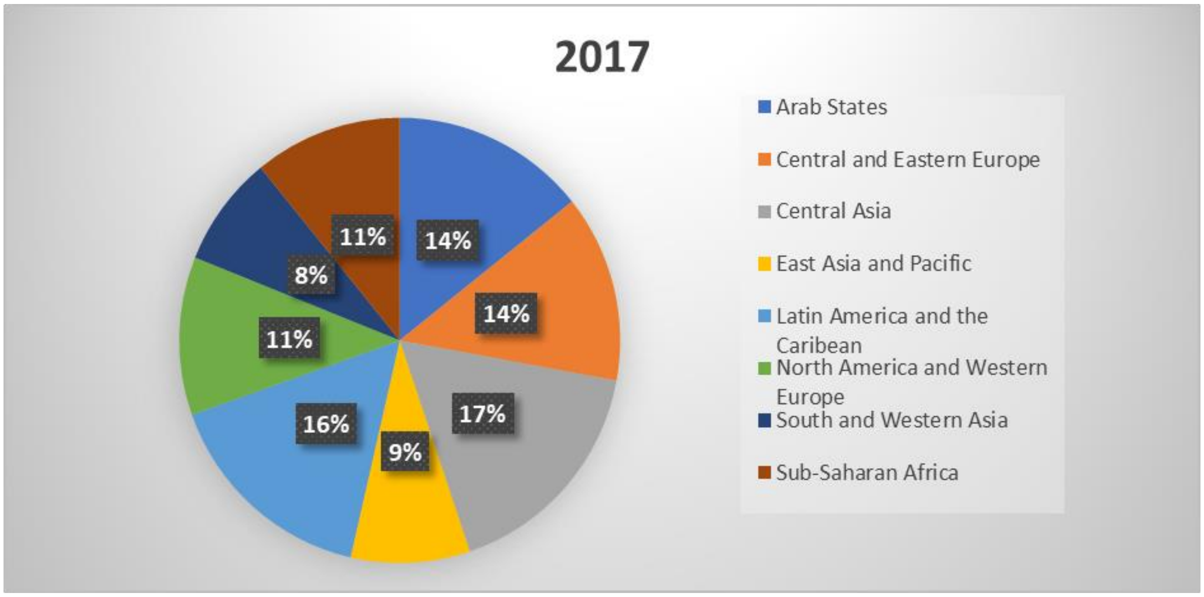


Figure 2. Pictorial representation of women in science in various continental regions for 2017

Figure 3 depicts the analytics comparison of different years for each continental region. The histogram shows the frequency distribution of women in science over each continental region.

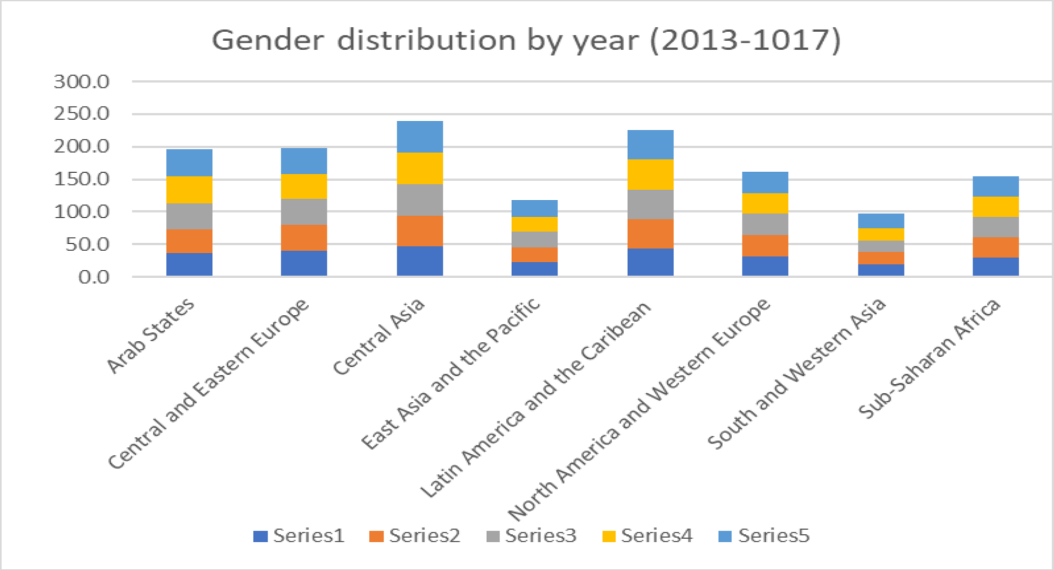
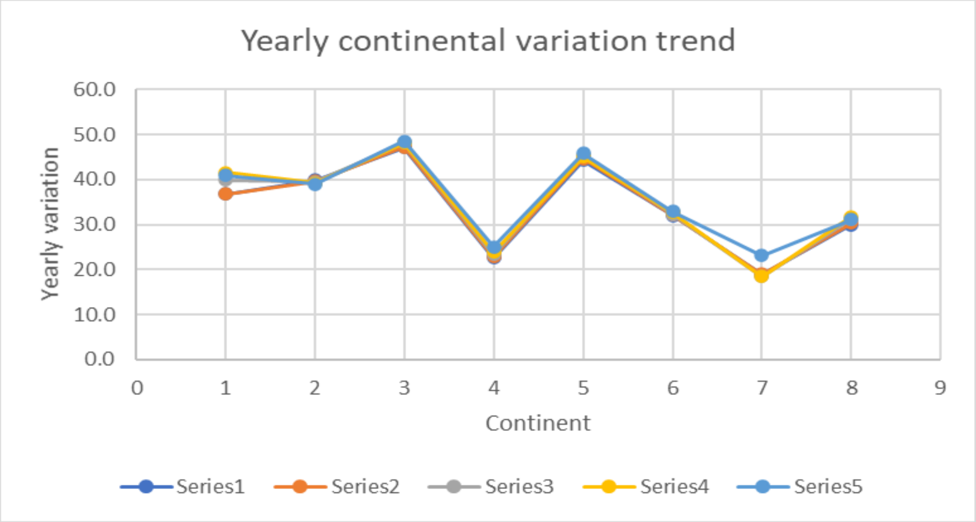


Figure 3. Analytics comparison of different years for each region

Figure 3 shows how the frequency distribution of women in science in different regions varies over time. Overall, Central Asia accounts for the highest increase in the attraction and recruitment of women into STEM, while East Asia and the Pacific depict the need to provide gender-inclusive solutions for a better future. Many studies have indicated varied reasons for women leaving the STEM sector, including a lack of career advancement compared to their male counterparts, gender-discriminatory organisational structures, and a lack of mentorship (Cummings, 2015). Figure 4 illustrates the fluctuating continental regions comparisons for different years, and Table 4 presents the correlation coefficient matrix of the different continental regions.



Yearly continental variation trend, where series 1=2013, series 2=2014, series 3=2015, series 4=2016, and series 5=2017.
Figure 4. Yearly continental regions variation trend

Table 4. Correlation coefficient matrix of different regions

	Arab States	*Central and Eastern Europe*		*Central Asia*	*East Asia and the Pacific*	*Latin America and the Caribbean*	*North America and Western Europe*	*South and Western Asia*	*Sub-Saharan Africa*
Arab States	1.000								
Central and Eastern Europe	-0.832	1.000							
Central Asia	0.961	-0.904		1.000					
East Asia and the Pacific	0.825	-0.974		0.909	1.000	1			
Latin America and the Caribbean	0.812	-0.912		0.938	0.900	1.000			
North America and Western Europe	0.875	-0.977		0.898	0.968	0.835	1.000		
South and Western Asia	0.326	-0.706		0.510	0.794	0.633	0.662	1.000	
Sub-Saharan Africa	0.937	-0.710		0.854	0.634	0.703	0.740	0.035	1.000

In Table 4, positive values indicate an increase or a strong relation between the compared continental regions, and the opposite is true for the negative values, except for the relation between Sub-Saharan Africa and South and Western Asia (0.035, $p < 0.05$). The CC with the lowest value indicates the level of the relationship between the compared continents to reveal how it varies with time. Exponential smoothing was used to fit a statistical model to predict the yearly continental trend for women in science. The performance of the annual trend measurement in comparison with the forecasted continental trend is illustrated in Figures 5 and 6. The CC and RMSE with the lowest value indicate the model fitting strength.

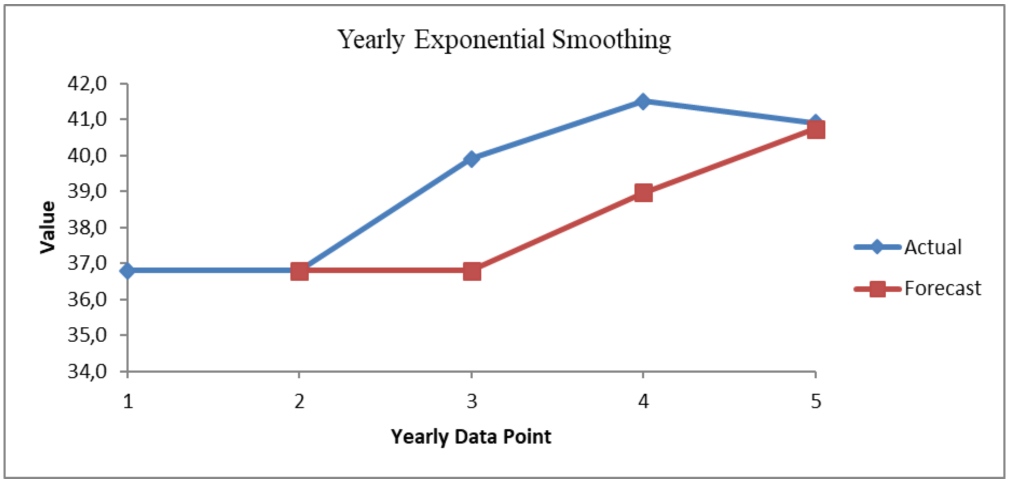


Figure 5. Forecasting the yearly trend over the continental regions

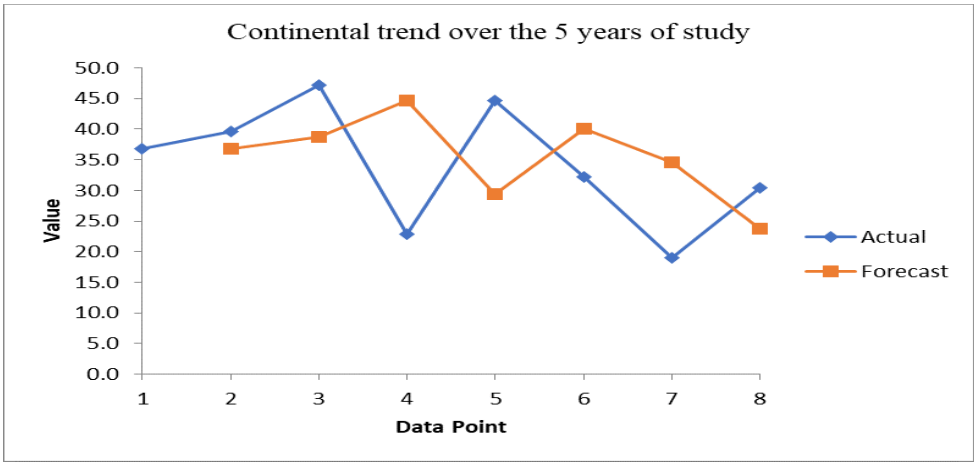


Figure 6. Forecasting each continental region's trend over the five years of study

In terms of the yearly continental data in Figure 5, there was a large gap between the actual and the forecasted data – this may be due to the residual error taken at time t, which does not correlate well with the measurements taken at time t-k. Figure 6, on the other hand, depicts how well the projected women's continental regions data follows the same pattern as the actual data. This implies that the developed forecasted trend model shows a strong likelihood for the representation of women disparity among the different continents. This does not portray a good reliability distribution in women's participation. Table 5 includes the coefficients of statistical performance, with a comparison by year and continent.

Table 5. Coefficients of statistical performance comparison

	Year	Regions
R^2	0.045	0.650
Adjusted R^2	0.076	0.045
RMSE	0.023	0.325

With logistic regression, we modelled the natural log odds as a linear function of the explanatory variable. Thus, the logistic regression analysis of other continents' women in science was compared to the world average to reveal whether it was high or low—a high/low F, with F(a, b, c, d, e, f, g, h) being a binary logit function, where F is the world (global) average; a, the Arab States; b, Central and Eastern Europe; c, Central Asia; d, East Asia and the Pacific; e, Latin America and the Caribbean; f, North America and Western Europe; g, South and Western Asia; and h, Sub-Saharan Africa. The Akaike's Information Criterion (AIC) value and the residual measured sum-of-squares errors were used to obtain the best-fit model. The results of the logistic regression model are given in Table 6. The logistic regression equation is presented as in Equation 2:

$$Y = -12111.41 - 0.014*a + 0.000*b + 0.7000*c - 0.6586*d + 0.000*e + 0.0069*f + 0.000*g - 0.0043*h \quad (2)$$

Table 6. Statistics of the predictors in the logistic regression model

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-12111.41	0.852	-14221.1	0.0000	-12113.3	-12109.6
Arab States	-0.014	0.000	-4290.12	0.0000	-0.0136	-0.0136
Central and Eastern Europe	0.000	0.000	-1194.97	0.0000	0.0000	0.0000
Central Asia	0.000	0.000	65535.00	0.0000	0.0000	0.0000
East Asia and the Pacific	0.6586	0.000	57497.20	0.0000	0.6586	0.6587
Latin America and the Caribbean	0.0000	0.001	-0.0810	0.9370	-0.0003	0.0003
North America and Western Europe	0.0069	0.0045	1.5283	0.1574	-0.0032	0.0169
South and Western Asia	0.0000	0.0000	-0.6865	0.5080	0.0000	0.0000
Sub-Saharan Africa	-0.0043	0.0023	-1.8977	0.0870	-0.0094	0.0007

In Table 6, a positive coefficient with a p-value < 0.05 indicates a directly proportional relationship between the variables (high), while a negative value indicates an inverse relationship (low). Based on the measured data, the Arab States and Sub-Saharan Africa have contributed negatively (non-significant) to the global women in science, while other continental parameters gave a positive value for other continents to illustrate their level of contribution. From Table 7, the study concluded that the computed pseudo R square for the goodness of fit implies that other continental variables are significantly associated with global women in STEM. Although there is substantial individual variability that these variables cannot explain, this reflects that other system factors are responsible for women's parity in professional jobs. The model with the lowest AIC and residual error represents the best goodness of fit analysis.

Table 7. Logit regression statistics

Null deviance	589.41
Residual deviance	543.90
AIC	569.50
Pseudo R Square	0.59
Standard Error	0.003443
Observations	21

From the ANOVA fit results in Table 8, the comparison level of other continents to the world average women participation in research shows that the probability value for the F-critical test statistic (2.714) has a p-value less than 0.05 (5% level of significance), which indicates that the model is adequate. This implies that the association of the predictors significantly combines with and relates well to the global women representation. In addition, one can refer to the null hypothesis H_{01}, which states that there is no difference between continental groups or no relationship between variables. However, since the p-value is less than 0.05, there is a significant relationship between other continental women's representation and the global women variables. Thus, there is a low occurrence or paucity of women in the STEM profession across the continents.

Table 8. ANOVA Test on continental regions data

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	18.256	4	4.564	4.724	0.005	2.714
Columns	3468.832	7	495.547	512.913	0.000	2.359
Error	27.052	28	0.966			
Total	3514.14	39				

Table 8 reveals a statistically significant impact on global continental women's inclusion in comparison to each continental contribution of women researchers in STEM. The global aggregated continental study data indicates a high perceived number F (512.913) = F crit (2.359), P=0.000 < 0.05, to signpost a significant relation. The mean and standard deviation ranges (M=33.95–35.125, SD=99.757–106.836) for Europe, North America, and Western Europe show an increasing trend over the measured years. The perception of lower success for women in STEM was witnessed in Sub-Saharan Africa and Latin America. Using PCA as a choice of FA Table 9 indicates the contribution of the squared cosine of the factor variables, identifying most significant variables that affect women in STEM on different continents through an explorative literature review. It can be observed that factor loading, as depicted in Figure 7 (values of F1–F3 in bold from Table 9), explains the degree of most of the identified contributing variables. Thus, PC1 is a more significant component than both PC2 and PC3. Using the corresponding factor loading value as in Table 9, the scores on PC1 can be computed as in Equation 3, while the scores on PC2 and PC3 can also be estimated from F2 and F3, respectively.

$$\mathrm{PC1} = 0.668 \times A + 0.824 \times B + 0.743 \times C + 0.786 \times D + 0.680 \times E + 0.786 \times F + 0.859 \times G + 0.115 \times H \tag{3}$$

Table 9. Contribution of the squared cosine of the factor variables

	F1	F2	F3
Arab States	**0.668**	0.003	0.013
Central and Eastern Europe	**0.824**	0.032	0.003
Central Asia	**0.743**	0.121	0.015
East Asia and the Pacific	**0.786**	0.007	0.046
Latin America and the Caribbean	**0.680**	0.005	0.016
North America and Western Europe	**0.798**	0.004	0.006
South and Western Asia	**0.858**	0.014	0.099
Sub-Saharan Africa	0.115	**0.890**	0.003

Note: For each variable, the values in bold correspond to the factor for which the squared cosine is the largest

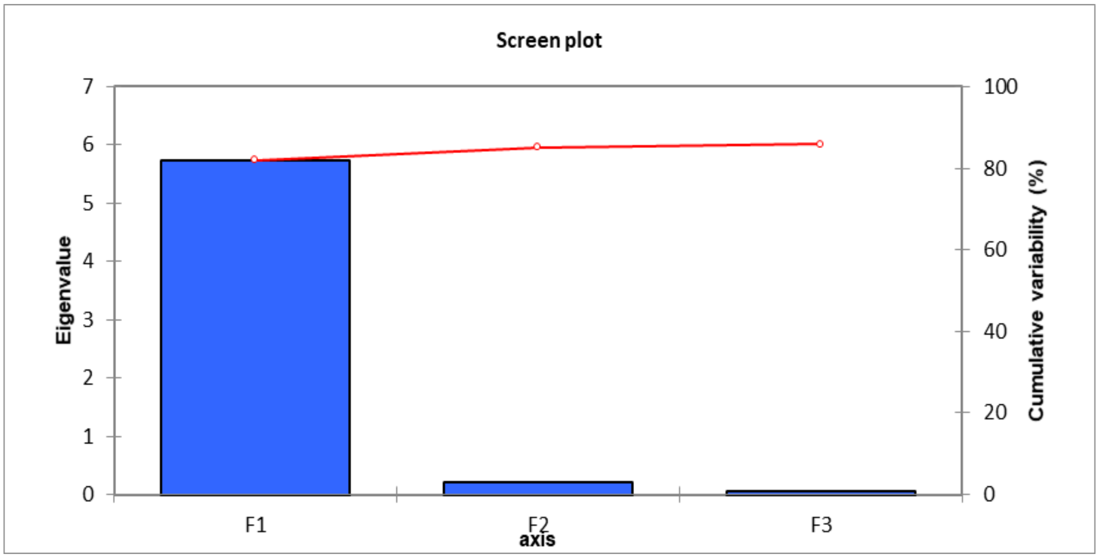


Figure 7. Factor analysis

These results indicate the factor variables' squared cosine contribution for the documented factors, which may be due to gender bias, family life, mentoring, and stereotypical considerations. The results show that a higher level of education allows women to participate more confidently in Europe and other continents compared to Sub-Saharan Africa. This shows how education is a powerful force to rectify an erroneous world outlook and promote a rational causal attribution that is fundamental to nurturing a spirit of self-worth and a realistic assessment of women's value in STEM professions. Table 9 shows that F1 (gender bias) accounts for the highest variance of 82.10%, while F2 (family life) and F3 (mentoring) explain approximately 8.07% and 2.03% of the total variance, respectively.

5. Conclusions

This study offered a quantitative assessment of women's disparity in STEM, comparing different continental regions over a 5-year period and considering the world (global) average of women in STEM. The explored best-fit exponential model showed a downward trend and a threat to women's inclusion in science. Thus, the assumption that women are increasingly assuming positions once considered "male" roles, overcoming outdated stereotypes, and thriving and succeeding in the STEM profession on different continents is far from true. The developed forecasted trend model shows the likelihood of disparity in women's representation, which does not portray a good reliability distribution in women's participation. The overall results showed the adequacy of multivariance correlation and factor analysis for developing a modelling framework to satisfy inquiry for equality inclusion of women in science over the documented distribution of the different continents for gender empowerment. The insight gained from the different verified continental yearly data indicates the need for real-time data usage on the different continents for affirmation investigations.

Institutional leaders need to provide a conducive environment where women can participate freely in science and research. Understanding the stereotypes, gender biases, and policy failures are critical to avoid perpetuating women's challenges. McKinnon and O'Connell (2020) believe that by observing and evaluating individual responses to stereotypes ascribed to women in STEM, one may better understand where one's prejudice stems from and how to confront it. It also allows one to look into the impact of role modelling on and openly discuss science with women in STEM. In addition, understanding stereotypes and one's reactions to them could lead to the creation of more effective methods to support women in STEM who take on leadership roles. The developed applied explorative literature review and procedural model are limited to secondary aggregated mean percentage data. Thus, caution should be exercised in considering the deduced inferences and perceptions formed to visualise the latent information in each continental quoted value. This paper has contributed to the literature on women in science from different continental regions and provides a picture of the levels of participation and the challenges women encounter in their quest to make a mark in a field that men dominate. Future research should focus on a comparative analysis of the challenges that women encounter in different regions or continents and country-focused research. This will facilitate an understanding of the prevalent challenges in a particular region or country, thereby enabling policy makers to develop targeted interventions.

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