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USING CLUSTER ANALYSIS FOR REVEALING GENDER EQUALITY PATTERNS IN EU ICT EDUCATION AND EMPLOYMENT

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ABSTRACT

Women are underrepresented in all aspects of ICT, including education and employment. This issue can be attributed to a lack of encouragement and opportunities for women to pursue ICT careers, as well as implicit biases and stereotypes leading to women being overlooked for roles in the industry. Cluster analysis is a useful tool for analyzing and grouping data to identify patterns and trends. This article aims to investigate the state of gender equality in information and communication technology education and employment across the European Union member-states using cluster analysis. The study uses data from the Eurostat to determine the female to male ratios of new bachelor entrants studying information and communication technologies, as well as employees working in the ICT in EU member-states. The article distinguishes gender equity leaders, adopters and laggards among EU member-states. The data was organized into six clusters of EU member-states with a focus on gender equality among those who enter into bachelor-level ICT programs and are employed in the field. Moreover, the article examines the ratio of female to male enrolled in information technology in Ukraine analyzing the case of the State University of Trade and Economics. It was found that the ratio of female to male does not have a stable upward trend. The article proposes some initiatives aimed at increasing the number of girls and women in ICT. This study provides valuable insights into the current state of gender equality in the ICT sector across EU member-states. The findings of this study can inform policymakers and stakeholders in developing targeted interventions to address gender inequality in the ICT sector. This will promote a more inclusive and diverse ICT workforce, which is essential for economic growth and social development.

Keywords: *Cluster Analysis, EU member-states, Female Empowerment, Gender Equality, Information Communication Technology, Gender Diversity Management*

1. INTRODUCTION

Gender inequality remains a persistent concern in ICT education and employment across the European Union (EU). Despite existing efforts, disparities in participation and opportunities for women in the field persist. A comprehensive understanding of these disparities and their underlying factors is lacking, impeding effective policy formulation and intervention strategies. Existing research has highlighted the need for innovative methodologies to categorize member-states based on their gender equality efforts. This study aims to address this gap by introducing a modified EU NUTS methodology and utilizing k-means cluster analysis, providing a refined framework for classifying countries and offering insights into gender equality patterns in ICT education and employment across the EU.

This article aims to investigate the state of gender equality in ICT education and employment across the European Union (EU) member-states using cluster analysis. The analysis will categorize countries based on their levels of gender equality in ICT, as measured by various indicators such as the female to male ratio of new bachelor entrants majoring in information and communication technologies in EU member-states and the female to male ratio of employees in ICT.

By identifying clusters of countries with similar characteristics and challenges, policymakers and stakeholders can better understand the barriers to gender equality in ICT education and employment and develop targeted interventions to address them. The results of this analysis can also serve as a benchmark for tracking progress over time and comparing gender equality in ICT across different regions and countries.

Overall, this article serves as a valuable contribution to the ongoing conversation about gender equality in the ICT sector, highlighting the importance of high-quality education and equal employment opportunities for both men and women.

2. LITERATURE REVIEW

There are a number of publications about gender equality in STEM. Verdugo-Castro et al. [1] reviewed existing research on the gender gap in choosing higher education in STEM fields. They shed light on the influence of stereotypes and gender roles on decision-making regarding higher education. The European Union is on the way to close the gender gap, there are still high rates to be addressed. These authors pointed out in the paper [2] that notwithstanding women enrolling at university at equal or even higher rates than men, they enrol at lower rates than men in STEM. Holgado et al. [3] analyzed the perception of computing students concerning the gender gap in computer science studies.

Schlenker [4] observed that although girls outperform boys in educational achievement, women continue to earn less than men, have a higher risk of living in poverty and are less likely to hold leadership positions. Stable occupational segregation is one of the reasons for this inequality. Girls cannot take advantage of the promising earnings and career opportunities in STEM occupations if they do not choose these fields of study. However, even women who are engaged in scientific or technical research are more likely than men not to work in STEM field.

Vinska and Tokar [5] identified nine classes and five clusters of EU member-states based on their level of economic development and gender equality to help strengthen EU cohesion policy. These authors found that all more developed countries are gender equality leaders supporting women's emancipation, there are no gender equality laggards therefore the cohesion policy positively influences on gender equality. Authors et al. [6] assume that relatively low participation of women in this field is explained by educational prejudices. Stereotypes about the low potential of women in STEM lead to a refusal to choose this profile in education. The article evaluates quantitative indicators, the study of environmental principles of communication including social experience, empathetic behavior and emotional intelligence. The authors et al. [7] categorize EU member-states and Ukraine based on women's participation in business. They use k-means clustering and the elbow method to group countries by female leadership in ownership and top management. Gender equality gaps are minimal among EU members and Ukraine for female top management in gender-committed groups, but gaps exist in female ownership. The EU's female-majority-owned firms (40.2%) exceed female-led top management (21.0%) by almost double. Ukraine excels in ownership equality and embraces top management change, while Sweden lags. Missing data from 12 EU nations affects the study's credibility. Policymakers can employ these findings to address gender disparities. The study identifies seven categories and five clusters of female empowerment in business across EU states and Ukraine based on ownership and top management ratios.

Kenny and Donnelly [8] interviewed 57 technically experienced female IT professionals in the UK. The authors found out how women encounter the gender structure in IT, how they are included in it and the narrative that women lack technical ability remains largely unchanged, in spite of their skills and efforts to interrupt this structure. The gender structure encourages or rewards women to fill hybrid roles, accordingly minimizing the presence of technically skilled women. They feel the need to restore and maintain their gender identity in response to the gender structure challenges. The limitations of this study include obtaining perspectives only from women. There are no observation of gender behavior of men in IT, study of perceptions of attitudes and behavior towards women and how they are changing.

Lagesen et al. [9] studied and discussed the results of the project on atrecruiting and retaining women students in ICT engineering programs at the university in Norway. They identified possible drivers and barriers to success in increasing the number of women in ICT. These authors observed that as the proportion of women increases, the probability of men's dropout decreases. Gender balance makes the culture more inclusive for all because more gender-balanced programs are more attractive to men and women. The scientists emphasized the importance of addressing the issue of recruiting women into academic positions in science. This is a way of trying to involve women in engineering more sustainably.

Hermans et al. [10] explored correlation between patterns in motivation profiles towards integrated STEM (iSTEM), gender and STEM test scores. They established four different motivational profiles using cluster analysis in a sample of 755 eighth-grade students. The authors showed that girls are more likely than boys of the same ability to belong to the high amotivation profile cluster. However, girls in this cluster have on average a significantly higher test score compared to boys. Thus, we can see the different influence of motivation profiles.

Gender gap in Computer Science has been studied by Lacave et al. When the mother is the main contributor to the family income, students are more aware of the need for equal rights, the importance of closing the gender gap, the more difficulties of women to find a technological job [11].

Chan's research on gender differences in self-efficacy, interest and aspirations in STEM showed that girls were less likely than boys to perceive themselves as having the ability to perform well in math, science and engineering tasks. This can cause girls to lose interest in STEM and, as a result, lack motivation to pursue academic and career pursuits. The study included a sample of 3020 secondary school students in China to investigate how cultural and gender norms influence STEM involvement. Access to female role models and gender-sensitive pedagogy through curriculum enrichment and outof-school time programs are necessary to close the gender gap in STEM [12]. However, the results of this study could be subject to common method bias due to relying solely on self-report data.

As Verdin's survey of female engineering students of nine US institutions found, women's engagement and identity formation are critical to their decision to pursue STEM education. Educators' socializing messages of who fits and belongs in engineering can damage a student's self-concept [13].

Although EU member-states are making efforts to achieve gender equality in research and innovation (R&D), all of them still face significant challenges in advancing the development of their innovation system. At the same time, gender equality is improved by using all available research potential. Striebing et al. analyze the development of the share of female researchers in the national innovation systems in Austria, Denmark, Hungary and Spain in the period 2005-2015 [14]. The authors highlighted that the proportion of women among the highly educated and research personnel has increased. Nonetheless, except for Spain, there have been no significant changes in the participation of women in the labour market in the comparison countries.

Kamau et al. gave examples of measures that will support women to pursue careers in academic research. These include establishing a female quota in senior academic positions, financial and organizational support for female researchers during parental leave, mentoring programs for young female researchers or equal opportunities for grants [15].

It is often stated that the scientific community should make efforts to educate junior female researchers in order to reduce the gender gap. However, Huang et al. [16] found that this may not be enough, as the academic system is losing women at a higher rate at every stage of their careers. The cumulative impact of this effect dramatically increases the gender disparity for senior mentors in academia, perpetuating a cycle of lower retention and promotion of female faculty.

Although the number of women receiving postgraduate degrees has increased in recent years, the number of women in STEM faculty remains almost unchanged. Casad et al. [17] described factors that may contribute to gender inequality and women's departure from academic STEM fields: numeric underrepresentation and stereotypes, lack of supportive social networks and a chilly academic climate. The authors observed potential solutions to these problems: interventions aimed at recruiting diverse candidates (eg, training search committees), mentoring, networking and professional development (eg, promoting women faculty networks) and improving the academic climate (eg, training male faculty on gender bias).

Women are significantly under-represented among ICT specialists in all EU member-states, in contrast to overall employment, where the genders are largely balanced. Universities in Europe have set up projects, internal policies and strategies aimed at increasing and retaining female students and researchers in computer science [18]

The share of ICT employment that was accounted for by men stood at 80.9 % in 2021, which was 2.1 percentage points lower than it had been in 2012. In 2021, about 9 out of 10 ICT specialists in Czechia, Hungary and Slovakia were men. While men accounted for about 8 out of every 10 ICT specialists in the majority of the remaining EU member-states, Malta, Romania and Bulgaria were the only member-states where the share of men was lower than 75 %. There were 20 EU member-states where the share of female ICT specialists rose during the period 2012 - 2021. The most striking progressions were observed in Malta where the share of women in the total number of ICT specialists rose up 15.2 percentage points, followed by Luxembourg and Portugal, up 9.3 and 6.5 percentage points respectively. By contrast, the relative share of men in the total number of ICT specialists rose the most in Greece, Bulgaria and Estonia, up by 4.1, 3.9 and 3.6 percentage points respectively [19].

3. METHODOLOGY

Our methodology incorporates the findings of researchers [5; 20; 21] disclosing methods for tackling gender gaps and clusters of EU member-states by gender equality.

Firstly, we modify the EU NUTS [22] methodology to distinguish gender equity leaders (more than 90 percent of average), adopters (75-90 percent), and laggards (below 75 percent) among EU member-states.

Secondly, we apply the k-means cluster analysis using the ratio of variance explained formula:

$$\text{Ratio of variance explained} = SSG/SST \quad (1)$$

Where:

SS – the sum of square distances accumulated over all points;

SSE – the sum of square distances within groups from the points to the centers;

SSG – the sum of square distances between groups from the centers to the average vector;

SST – the total sum of square distances from the points to the average vector, so that:

$$SST = SSE + SSG \quad (1)$$

The above-mentioned methods contribute to improving the set of instruments for solving the problem of gender gaps in ICT.

4. RESULT

4.1 Gender equality of entrants in “Information Technologies” in Ukraine

Women accounted for 18.4% of the bachelor students and 18.9% of graduates of information technologies in Ukraine in 2021.

The ratio of female to male enrolled at the State University of Trade and Economics (SUTE) in the field of study “Information Technologies” to obtain bachelor's degree in 2016-2022 is calculated in Table 1.

Table 1 indicates that the ratio of women to men enrolled in information technology increased to 0.28 for the period 2016-2022. However, it should be noted that the increase in the ratio of women to men in the specialties “Computer Science”, “System Analysis” and “Information Systems and Technologies” in 2020-2022 occurred not only due to an increase in the number of women, but also a decrease in the number of enrolled men. It is worth mentioning, that the number of female students is also increasing in the “Software Engineering” and “Cybersecurity” specialties, but the rate of growth of female students is slower than the rate of growth of male students. In 2022, compared to 2016, the ratio of female to male in “Computer Science” decreased by 0.11. Therefore, the ratio of female to male does not have a stable upward trend (refer to table 1 and figure 1).

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Table 1: The Ratio Of Female To Male Enrolled At The SUTE In The Field Of Study "Information Technologies" To Obtain Bachelor's Degree In 2016-2022 (Own Calculations)

Specialty	2016	2017	2018	2019	2020	2021	2022	Average	Change
Software Engineering	0,12	0,35	0,14	0,06	0,22	0,12	0,27	0,18	0,15
Computer Science	0,47	0,39	0,32	0,25	0,16	0,30	0,36	0,32	-0,11
System Analysis		0,15	0,43	0,32	0,84	0,73	1,20	0,61	1,05
Cybersecurity			0,08	0,09	0,18	0,16	0,12	0,13	0,04
Information Systems and Technologies					0,10	0,25	0,47	0,27	0,37
Total: field of study "Information Technologies"	0,24	0,34	0,20	0,16	0,21	0,22	0,28	0,24	0,04

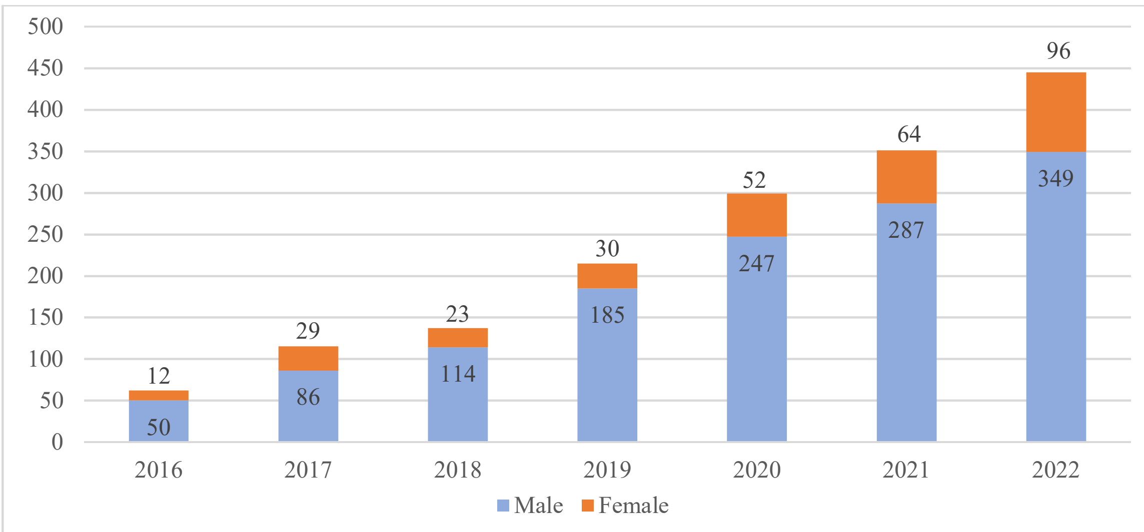

Figure 1: Number Of Enrolled At The SUTE In The Field Of Study "Information Technologies" To Obtain Bachelor's Degree In 2016-2022

4.2 Cluster analysis

Table 2 demonstrates that the EU average was 0,223 there were 13 gender equality leaders (Bulgaria, Denmark, Germany, Estonia, Ireland, Greece, Croatia, Latvia, Austria, Portugal, Romania, Finland, and Sweden), 7 adopters (Czechia, France, Cyprus, Luxembourg, Hungary, Malta, and Slovenia), and 7 laggards (Belgium, Spain, Italy, Lithuania, Netherlands, Poland, and Slovakia) among EU member-states considering female to male ratio among bachelor entrants in ICT in 2017-2020.

Table 2: The Female To Male Ratio Of New Bachelor Entrants Majoring In Information And Communication Technologies In EU Member-States In 2017-2020 (Own Calculations Based On [23])

Period	2017	2018	2019	2020	Average	Change	Rank	Percent of EU average in 2017-2020	Gender equality type
Belgium	0,09	0,14	0,13	0,13	0.123	0,03	27	55	laggard
Bulgaria	0,39	0,42	0,40	0,37	0.395	-0,02	2	177	leader
Czechia	0,20	0,19	0,18	0,19	0.190	-0,01	14	85	adopter
Denmark	0,18	0,21	0,22	0,25	0.215	0,07	11	96	leader
Germany	0,28	0,27	0,27	0,27	0.270	0,00	7	121	leader

Estonia	0,33	0,29	0,28	0,31	0.302	-0,02	5	135	leader
Ireland	0,24	0,24	0,25	0,24	0.243	0,00	9	109	leader
Greece	0,36	0,40	0,39	0,29	0.359	-0,07	4	161	leader
Spain	0,13	0,14	0,15	0,17	0.149	0,04	23	67	laggard
France	0,14	0,18	0,17	0,19	0.172	0,05	19	77	adopter
Croatia	0,29	0,28	0,29	0,27	0.283	-0,02	6	127	leader
Italy	0,16	0,14	0,14	0,16	0.148	0,00	24	66	laggard
Cyprus	0,15	0,23	0,18	0,15	0.177	0,00	17	79	adopter
Latvia	0,21	0,23	0,19	0,19	0.208	-0,02	12	93	leader
Lithuania	0,15	0,14	0,15	0,14	0.145	-0,01	25	65	laggard
Luxembourg	0,09	0,13	0,16	0,27	0.162	0,18	20	72	adopter
Hungary	0,18	0,20	0,17	0,19	0.186	0,00	15	83	adopter
Malta	0,16	0,17	0,18	0,18	0.172	0,02	18	77	adopter
Netherlands	0,11	0,13	0,14	0,15	0.133	0,04	26	60	laggard
Austria	0,26	0,24	0,26	0,27	0.259	0,01	8	116	leader
Poland	0,15	0,15	0,15	0,15	0.154	0,00	21	69	laggard
Portugal	0,22	0,16	0,21	0,22	0.205	0,00	13	92	leader
Romania	0,41	0,40	0,43	0,42	0.417	0,01	1	187	leader
Slovenia	0,17	0,16	0,19	0,21	0.184	0,03	16	82	adopter
Slovakia	0,15	0,15	0,14	0,15	0.151	0,00	22	68	laggard
Finland	0,20	0,21	0,25	0,26	0.232	0,06	10	104	leader
Sweden	0,41	0,41	0,39	0,38	0.395	-0,03	3	177	leader
Average	0,22	0,22	0,23	0,23	0,223	0,01	X	X	X

Table 3: The Female To Male Ratio Of Employees In Information And Communication Technologies In EU Member-States In 2017-2020 (Own Calculations Based On [24])

Period	2017	2018	2019	2020	Average	Change	Rank	Percent of EU average in 2017-2020	Gender equality type
Belgium	0,32	0,34	0,33	0,34	0.330	0,02	25	74	laggard
Bulgaria	0,58	0,59	0,54	0,57	0.571	-0,01	4	127	leader
Czechia	0,32	0,31	0,31	0,30	0.311	-0,02	27	69	laggard
Denmark	0,41	0,36	0,34	0,38	0.374	-0,03	21	83	adopter
Germany	0,48	0,49	0,47	0,42	0.467	-0,06	9	104	leader
Estonia	0,46	0,50	0,45	0,51	0.479	0,05	8	107	leader
Ireland	0,46	0,45	0,43	0,43	0.442	-0,03	12	99	leader
Greece	0,50	0,62	0,72	0,67	0.630	0,17	1	140	leader
Spain	0,45	0,40	0,44	0,47	0.442	0,03	13	98	leader
France	0,45	0,45	0,46	0,45	0.450	0,01	11	100	leader
Croatia	0,46	0,51	0,62	0,47	0.516	0,02	7	115	leader
Italy	0,43	0,40	0,42	0,43	0.421	0,00	17	94	leader
Cyprus	0,60	0,57	0,47	0,48	0.530	-0,12	6	118	leader
Latvia	0,60	0,68	0,72	0,44	0.608	-0,16	2	136	leader
Lithuania	0,66	0,50	0,57	0,66	0.600	0,00	3	134	leader

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Luxembourg	0,35	0,38	0,36	0,36	0.363	0,01	22	81	adopter
Hungary	0,38	0,31	0,34	0,35	0.345	-0,02	24	77	adopter
Malta	0,41	0,42	0,42	0,34	0.399	-0,07	20	89	adopter
Netherlands	0,33	0,32	0,34	0,30	0.323	-0,03	26	72	laggard
Austria	0,41	0,46	0,54	0,46	0.467	0,06	10	104	leader
Poland	0,47	0,45	0,39	0,39	0.426	-0,08	16	95	leader
Portugal	0,44	0,42	0,38	0,51	0.441	0,07	15	98	leader
Romania	0,60	0,55	0,52	0,58	0.565	-0,02	5	126	leader
Slovenia	0,40	0,41	0,49	0,46	0.441	0,07	14	98	leader
Slovakia	0,43	0,27	0,33	0,40	0.359	-0,02	23	80	adopter
Finland	0,35	0,37	0,44	0,46	0.405	0,11	18	90	leader
Sweden	0,40	0,38	0,39	0,43	0.399	0,04	19	89	adopter
Average	0,45	0,44	0,45	0,45	0,448	0,00	X	X	X

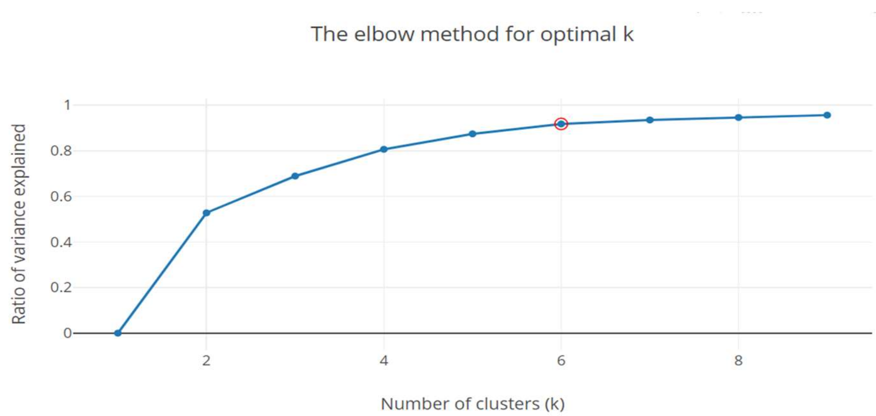

Figure 2: The Results Of Determining Number Of Cluster Applying The Elbow Method

Table 3 demonstrates that the EU average was 0,448 and there were 19 gender equality leaders (Bulgaria, France, Cyprus, Germany, Estonia, Ireland, Greece, Croatia, Latvia, Austria, Portugal, Romania, Finland, Slovenia, Spain, Italy, Lithuania, Poland, and Slovakia), 5 adopters (Sweden, Luxembourg, Hungary, Malta, and Denmark), and 3 laggards (Belgium, Czechia, and Netherlands) among EU member-states considering female to male ratio among employees in ICT in 2017-2020.

The data was divided into 6 clusters (Fig. 2). We chose the smallest k (number of clusters), which explains at least 90% of the variance (91.7382%).

Table 4 indicates that Cluster 1 consists of only 1 country (Sweden), Cluster 2 includes 9 (Denmark, Spain, France, Italy, Malta, Poland, Portugal, Slovenia, Finland) EU member-states, Cluster 3 embraces 6 (Belgium, Czechia, Luxembourg, Hungary, Netherlands, Slovakia) EU member-states, Cluster 4 – 3 (Bulgaria, Greece, and Romania), Cluster 5 – 5 (Germany, Estonia, Ireland, Croatia, Austria), and Cluster 6 – 3 (Cyprus, Latvia and Lithuania) EU member-states.

Table 4: The Descriptive Statistics For 6 Clusters Of EU Member-States Considering Gender Equality Among Bachelor Entrants And Employees In ICT

№	Cluster	Number of countries	Sum of square distances to the center	Centers
1	Sweden	1	0	[0.395; 0.399]
2	Denmark, Spain, France, Italy, Malta, Poland, Portugal, Slovenia, Finland	9	0.01239	[0.1812; 0.4221]
3	Belgium, Czechia, Luxembourg, Hungary,	6	0.005853	[0.1575; 0.3385],

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	Netherlands, Slovakia			
4	Bulgaria, Greece, Romania	3	0.004295	[0.3903; 0.5887],
5	Germany, Estonia, Ireland, Croatia, Austria	5	0.004944	[0.2714; 0.4742]
6	Cyprus, Latvia, Lithuania	3	0.005667	[0.1767; 0.5793]

SSE - The sum of squared of the distances from all the points to the centers.

SSE (Within): 0.03315.

SSG (Between groups): 0.3681.

SST (Total): 0.4012.

Maximum iterations: 15.

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6. CONCLUSION

In spite of abundant literature on problems and prospects of the ICT, this research is imperative as it addresses the persistent gender disparities prevalent in ICT education and employment across the European Union (EU). The study's significance lies in its comprehensive methodology, which amalgamates insights from prior researchers and introduces innovative approaches to tackle this pressing issue.

The research contribution of this study is

In comparison to other solutions presented in the field, our research stands out with several major findings and contributions that advance the understanding and implementation of gender equality in ICT education and employment within the European Union.

Firstly, our research introduces a modified version of the EU NUTS methodology, offering a refined and practical framework to categorize EU member-states based on their gender equality efforts. This modified methodology, which classifies countries as gender equity leaders, adopters, or laggards, enhances the precision of evaluation and policy formulation, providing a clear roadmap for addressing disparities.

Secondly, our utilization of k-means cluster analysis, coupled with the ratio of variance explained formula, presents a novel analytical approach to dissecting the complexities of gender equality patterns. By quantifying variance within and between clusters, our research contributes to a deeper understanding of the factors that shape gender equality outcomes, offering insights that can guide targeted interventions.

Moreover, our research goes beyond mere classification by investigating specific cases, such as the gender equality trends among "Information Technologies" entrants in Ukraine. This empirical examination adds a practical dimension to our findings, bridging the gap between theory and real-world implications.

Finally, our research uniquely combines a comprehensive methodological approach with a regional perspective, identifying distinct clusters of countries with differing gender equality outcomes. This offers policymakers and stakeholders a comprehensive view of the regional landscape, enabling them to draw inspiration from successful approaches and tailor interventions to specific contexts.

In summary, our research stands out through its modified methodology, analytical innovation, practical case studies, and regional insights. These findings collectively contribute to a more nuanced understanding of gender equality dynamics in the ICT sector and provide actionable insights that can drive positive change throughout the European Union.

The conclusion regarding the research problem was reached through a combination of methodological rigor, empirical analysis, and the integration of contemporary insights from existing literature.

Firstly, the utilization of a modified EU NUTS methodology, derived from previous research, established a structured approach to assess and categorize EU member-states based on their gender equality efforts. This criterion was justified as it provided a clear and standardized framework for evaluating disparities.

Secondly, the incorporation of k-means cluster analysis, coupled with the ratio of variance explained formula, enabled a data-driven examination of gender equality patterns across different clusters of member-states. This analytical criterion was chosen for its ability to provide statistical rigor and objective insights into the distribution of gender equality outcomes.

Moreover, the alignment of the research with up-to-date literature ensured that the conclusions were grounded in the latest understanding of gender disparities in the ICT sector. This criterion was essential to ensure the research's relevance, credibility, and resonance within the broader scholarly and policy discourse.

In summary, the conclusion regarding the research problem was reached by employing methodological precision, empirical analysis, and a literature-informed perspective, which collectively reinforced the credibility and significance of the findings.

The female to male ratio of new bachelor entrants majoring in ICT was calculated. Bulgaria, Denmark, Germany, Estonia, Ireland, Greece, Croatia, Latvia, Austria, Portugal, Romania, Finland, and Sweden were gender equality leaders. There were 7 adopters: Czechia, France, Cyprus, Luxembourg, Hungary, Malta, and Slovenia. There were 7 laggards: Belgium, Spain, Italy, Lithuania, Netherlands, Poland, and Slovakia.

The female to male ratio of employees in information and communication technologies in EU member-states in 2017-2020 was also calculated. Sweden, Luxembourg, Hungary, Malta, and Denmark were adopters and Belgium, Czechia, Netherlands were laggards. Other 19 EU member-states were gender equality leaders.

The data was grouped into six clusters of EU member-states considering gender equality among bachelor entrants and employees in ICT. Cluster 1 consists of Sweden, Cluster 2 embraces Denmark, Spain, France, Italy, Malta, Poland, Portugal, Slovenia, and Finland. Cluster 3 includes Belgium, Czechia, Luxembourg, Hungary, Netherlands, and Slovakia. Cluster 4 consists of Bulgaria, Greece, and Romania. Cluster 5 includes 5 EU member-states (Germany, Estonia, Ireland, Croatia, and Austria). Cluster 6 embraces Cyprus, Latvia, and Lithuania.

The cluster analysis highlights the heterogeneity of gender equality in ICT education and employment across the EU, with some countries performing significantly better than others.

While the ratio of women to men enrolled in Information Technology programs at the State University of Trade and Economics in Ukraine has increased slightly over the past few years, the progress has not been consistent across all specialties. The rate of growth of female students in “Software Engineering” and “Cybersecurity” specialties is slower than that of male students. Therefore, while there has been some progress towards gender diversity in Information Technology field, more efforts are needed to achieve a more balanced representation of women in this field.

Initiatives aimed at increasing the number of girls and women in ICT should start from school. Raising awareness of gender equality issues and introducing gender-sensitive approaches in the design and delivery of activities/lessons can increase girls' interest in STEM and facilitate the choice of ICT areas for further education. It is worth adding organization of meetings about women’s professions in various scientific and technological directions and meetings with inspiring women in ICT, participation in events: Hackathons for teachers and for girls, Mentoring program, National Day of Girls in Technology, Day of Girls in ICT and other events.

Career counseling can be held in schools and relevant events at the universities, helping students in the implementation of their own projects to attract students to future activities in STEM. For instance, as a result of the National Open Days for Girls Only held by technical universities, the share of girls involved in STEM education in Poland has increased from 29% to 37% in 11 years [25].

Promoting gender equality in ICT employment can have positive impacts on management effectiveness and organizational performance.Gender-diverse teams are more likely to bring a range of perspectives and experiences to the table, which can lead to more innovative and creative solutions. This is particularly important in the fast-paced and rapidly evolving field of ICT, where new ideas and approaches are essential for success. Promoting gender equality in the workplace can lead to higher levels of employee engagement and retention. Employees are more likely to stay with the company for longer periods of time. Companies that give importance to achieving gender equality are probable to have an improved public image and be perceived as more committed to social responsibility. This approach may aid in the attraction and retention of high-quality personnel, as well as enhancing the relationships with customers and stakeholders.

By fostering diverse perspectives, improving decision-making, enhancing employee engagement and retention, and improving reputation, gender equality in ICT employment can be a catalyst for success in the industry. However, achieving gender equality requires ongoing commitment and effort from organizations, including addressing bias and discrimination, promoting diverse hiring practices, and creating a supportive and inclusive workplace culture.

By adopting policies that promote equal access to education and employment opportunities, and eliminating gender biases and stereotypes, EU member-states can create a more inclusive environment that encourages women's participation in ICT-related fields. However, the benefits of a more inclusive and diverse workforce are significant for everyone involved in the field.

Despite its contributions, this research has certain limitations. Firstly, the classification of member-states into gender equity leaders, adopters, and laggards relies on predefined percentage thresholds, potentially oversimplifying the complex dynamics of gender equality efforts. Additionally, the use of k-means cluster analysis may not capture all nuances within the data, potentially overlooking subtle patterns that could provide deeper insights.

Furthermore, the research's focus on the EU context might limit the generalizability of findings to regions with different socio-cultural contexts. The absence of qualitative data and contextual information also restricts a comprehensive understanding of the factors driving gender disparities.

Future research directions could involve incorporating qualitative methodologies to complement quantitative analyses, offering a more holistic view of the gender equality landscape. Exploring the impact of cultural and societal factors on gender equality patterns could provide deeper insights into disparities. Additionally, longitudinal studies could shed light on trends and trajectories, while a comparative analysis with other global regions could offer cross-cultural insights.

Furthermore, investigating the effectiveness of specific interventions aimed at bridging gender gaps and evaluating policy outcomes could inform evidence-based strategies. Ultimately, a multidisciplinary approach that combines sociological, psychological, and economic perspectives could enhance the understanding of gender equality dynamics in the ICT sector and facilitate more targeted and effective interventions.

7. AUTHOR CONTRIBUTIONS

Valentyna MAKOIEDOVA was responsible for conceiving and designing the analysis, collecting data, performing the analysis on the case of the State University of Trade and Economics, making conclusions and writing the paper. Volodymyr TOKAR was responsible for conceiving and designing the analysis, performing the analysis on clustering EU member-states, and writing the paper. Dmytro TYSHCHENKO, Tamara FRANCHUK, and Andrii LOTARIEV were responsible for conceiving and designing the analysis, and writing the paper.

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