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FROM NORM ADOPTION TO POLICY IMPACT: EXPLAINING THE MULTI-LAYERED IMPLEMENTATION GAP IN GENDER EQUALITY IN STEM IN NORTH MACEDONIA

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ABSTRACT

This article examines the gap between the formal adoption of gender equality policies and their substantive outcomes in the STEM sector in North Macedonia. Drawing on Europeanization and feminist institutionalism, the study employs a mixed-methods design combining policy analysis, longitudinal statistical data, and semi-structured interviews with key stakeholders.

The findings reveal a systematic decoupling between high levels of formal alignment with European Union and international frameworks and limited progress in practice. While women approach parity in STEM education, their transition into employment remains significantly constrained. Using a novel operationalization of the “leaky pipeline” through transition rates between education and employment, the study demonstrates that gender disparities are most pronounced at the point of labor market entry, indicating structural barriers beyond educational access.

The analysis shows that this implementation gap is produced by the interaction of four interrelated dynamics: weak operationalization of policy commitments, fragmented governance structures, limited integration of gender-disaggregated data into policymaking, and persistent socio-cultural norms shaping participation in technical fields. These findings highlight the limits of formal policy adoption in the absence of institutional and cultural transformation. By conceptualizing the implementation gap as multi-layered and introducing transition rates as an empirical indicator, the study contributes to the literature on Europeanization and gender equality by linking policy adoption to measurable outcomes within a sector-specific context. The results suggest that advancing gender equality in STEM

requires moving beyond formal compliance toward coordinated, data-driven, and context-sensitive interventions that address both structural and informal barriers.

Keywords: gender equality; STEM; policy implementation; Europeanization; feminist institutionalism; North Macedonia

INTRODUCTION

Across Europe, closing gender gaps in STEM is increasingly framed not only as a matter of fairness, but as a question of economic sustainability. Yet in many contexts, policy commitments have outpaced tangible results. This tension is particularly visible in the Western Balkans, where gender disparities in the labor market continue to carry significant economic costs, largely linked to the limited participation of women in high-growth technical sectors (Ferati et al., 2023).

North Macedonia offers a revealing case. Over the past decade, the country has aligned extensively with European gender equality frameworks promoted by the European Commission and embedded in initiatives such as Horizon Europe. On paper, this alignment suggests a strong institutional commitment. In practice, however, outcomes in the STEM workforce tell a more uneven story.

While women now outnumber men in overall tertiary education, their presence remains uneven across disciplines. Technology and engineering fields continue to be male-dominated, and this imbalance extends into the labor market, where highly educated women face persistently higher unemployment rates. The contrast between educational attainment and employment outcomes points to deeper structural constraints that are not addressed by formal policy frameworks alone.

This disconnection reflects what can be understood as an implementation gap, where policy adoption does not translate into effective change. Existing research suggests that such gaps are common in contexts where external alignment with EU norms is not matched by domestic institutional capacity. In North Macedonia, gender equality policies often remain programmatic, meeting formal requirements without producing sustained transformation in practice.

At the same time, institutional explanations alone are insufficient. Educational choices and career trajectories are also shaped by less visible factors, including organizational cultures and socio-cultural norms that continue to frame technical fields as male domains. These dynamics limit the impact of policies focused primarily on access, as formal inclusion does not necessarily lead to equal participation or outcomes.

Against this background, this study examines the mechanisms that sustain the implementation gap in gender equality policies within the STEM sector in North Macedonia. It asks three related questions: how closely formal policies align with European standards and what constrains their implementation; how governance structures and data limitations shape the transition from education to employment; and how socio-cultural norms interact with, and at times undermine, formal policy efforts.

The article argues that the implementation gap is best understood as multi-layered, emerging from the interaction between institutional constraints, governance practices, data use, and socio-cultural dynamics. By bringing these dimensions together, it offers a more integrated account of why formal policy alignment does not automatically lead to substantive

outcomes. In doing so, it contributes to ongoing debates on Europeanization and gender equality, while providing an empirically grounded perspective on the challenges of advancing gender equality in STEM in EU accession contexts.

LITERATURE REVIEW

Gender Equality in STEM as a Policy and Governance Challenge

The integration of women into Science, Technology, Engineering, and Mathematics (STEM) is increasingly framed as both a social and economic priority. In the Western Balkans, gender disparities in labor market participation are associated with significant economic costs, with estimates suggesting that up to 18% of regional GDP is lost due to the underrepresentation of women in high-growth sectors, particularly technology and engineering (World Bank, 2018). This estimate originates from regional studies indicating that gender gaps in the labor market cost the Western Balkans approximately **18% of their GDP** (World Bank, 2018). This significant economic loss is largely attributed to the systemic underrepresentation of women in high-productivity, high-growth sectors such as technology and engineering (Ferati et al., 2023). Within this regional context, North Macedonia presents a notable case of divergence between formal policy commitments and substantive outcomes.

Over the past decade, the country has achieved a high degree of alignment with European gender equality frameworks, including the European Commission Gender Equality Strategy and requirements under Horizon Europe, such as the adoption of institutional Gender Equality Plans (European Commission, 2020; Irod et al., 2025). At a formal level, these developments indicate strong compliance with EU norms. However, this alignment has not translated into proportional outcomes within the STEM sector.

Although women now surpass men in overall tertiary education enrollment, their participation remains uneven across disciplines, with persistent underrepresentation in technology-oriented fields (Taravari et al., 2025; Reka & Memeti, 2024). At the same time, highly educated women face disproportionately high unemployment rates, suggesting structural barriers in the transition from education to employment. This divergence reflects what can be understood as an implementation gap, where formal policy adoption fails to produce substantive change.

Existing scholarship suggests that such gaps are not merely technical but reflect deeper institutional and socio-cultural dynamics. Gender equality policies often remain programmatic, emphasizing formal compliance while failing to address underlying practices and norms that shape educational and labor market outcomes (Anagnostou, 2022; Verloo, 2005).

Europeanization and the Limits of Norm Adoption

Europeanization provides a central analytical lens for understanding the diffusion of gender equality norms in EU accession contexts. It refers to the process through which European-level rules and policy frameworks are incorporated into domestic systems (Radaelli, 2003). In enlargement contexts, this process is largely driven by conditionality, whereby candidate countries adopt EU standards in exchange for progress toward membership (Schimmelfennig & Sedelmeier, 2005).

While Europeanization has been effective in promoting formal compliance, particularly in legislative harmonization, its impact on implementation remains uneven (Börzel & Risse, 2003; Olsen, 2002). A growing body of literature highlights the distinction

between rule adoption and rule application, emphasizing that the transposition of norms does not necessarily lead to substantive institutional change (Noutcheva, 2012; Димитрова, 2010).

In Southeast Europe, this dynamic is often described as “shallow Europeanization,” characterized by the adoption of formal frameworks without corresponding transformation in practice (Economides & Ker-Lindsay, 2015; Gordy & Efendić, 2019). Institutional constraints, including limited administrative capacity, fragmented governance structures, and weak enforcement mechanisms, frequently limit the effectiveness of policy implementation (Knill et al., 2009; Zhelyazkova et al., 2017).

Moreover, the success of norm diffusion is mediated by domestic conditions such as political will, institutional coordination, and societal attitudes (Cortell & Davis, 2005; Upadhyaya, 2017). Gender equality in STEM represents a particularly complex case, as it requires not only regulatory compliance but also changes in deeply embedded social norms and professional cultures (Charles & Thébaud, 2018; Linková & Mergaert, 2021).

Feminist Institutionalism and Gendered Structures

To explain the persistence of gender inequalities despite formal policy alignment, feminist institutionalism provides a complementary perspective. This approach emphasizes that institutions are not neutral but are shaped by historically embedded gender norms and power relations (Acker, 1990; Mackay et al., 2010).

Institutional practices and organizational cultures often reproduce inequalities, even in the presence of formal commitments to gender equality. Acker’s (1990) concept of gendered organizations illustrates how workplace norms and structures can privilege masculine models of work, thereby constraining women’s participation and advancement.

Institutional change is further complicated by what has been described as institutional “stickiness,” referring to the persistence of established practices over time (Mackay et al., 2010). New policies are frequently adapted to existing institutional logics, limiting their transformative potential (Benschop & Verloo, 2006). As a result, gender equality measures may be formally adopted but remain weakly implemented in practice.

The framing of gender equality also shapes policy outcomes. When framed primarily as an economic or technical issue, rather than as a structural inequality, policies may prioritize formal indicators over substantive change (Ferree, 2012; Verloo, 2007). In contexts where societal support is limited, such framing may lead to partial or symbolic implementation (Anagnostou, 2022; Black, 2009).

These dynamics are particularly relevant in STEM, where institutional practices intersect with cultural norms to shape participation and career trajectories.

Structural and Socio-Cultural Dimensions of Gender Inequality in STEM

Research on gender inequality in STEM consistently identifies the interaction between structural constraints and socio-cultural dynamics. One of the most persistent patterns is horizontal segregation, whereby women are concentrated in certain fields, such as life sciences, while remaining underrepresented in engineering and information technology (Charles & Bradley, 2009; Shen, 2013).

Socio-cultural explanations emphasize the role of gender socialization and stereotypes in shaping educational and career choices. From an early age, individuals are exposed to norms that associate technical competence with masculinity, influencing both aspirations and perceived opportunities (Eccles, 1994; Cheryan et al., 2017). These patterns are reinforced by

the limited visibility of female role models and by institutional environments that may implicitly signal exclusion (Ong et al., 2011).

The concept of “ambient belonging” further highlights how subtle environmental cues, such as classroom dynamics or workplace culture, influence individuals’ sense of inclusion (Cheryan et al., 2009). Even in the absence of formal barriers, such cues can discourage participation and contribute to attrition over time.

Labor market dynamics reinforce these inequalities. Women in STEM often face barriers related to hiring practices, career progression, and work-life balance, contributing to the “leaky pipeline” phenomenon, where participation declines across educational and professional stages (Fox, 2001; Moss-Racusin et al., 2012; Makarova et al., 2016).

Importantly, these structural and cultural factors interact with policy frameworks. Policies that focus primarily on access, without addressing underlying institutional and cultural dynamics, are unlikely to achieve sustained impact.

Policy Implementation and Governance Capacity

The literature on policy implementation emphasizes that the effectiveness of public policies depends not only on their design but also on the capacity of institutions to implement them (Hill & Hupe, 2002; Pollitt & Bouckaert, 2011). Implementation is shaped by factors such as resource availability, administrative coordination, and institutional accountability (Bolognesi et al., 2017).

Gender equality policies present particular challenges in this regard, as they require coordination across multiple policy domains, including education, labor, and social policy. In contexts characterized by fragmented governance, responsibilities are often dispersed, limiting accountability and reducing policy effectiveness.

The availability of reliable data is another critical factor. Gender-disaggregated data are essential for identifying disparities and designing targeted interventions, yet gaps in data systems often limit evidence-based policymaking (Percival et al., 2023).

An important analytical perspective is provided by the concept of a “Type III error,” which occurs when a policy is judged ineffective despite not being properly implemented (Chriqui et al., 2023). In the case of North Macedonia, apparent policy failure may reflect limited operationalization rather than flawed design, particularly in relation to gender mainstreaming initiatives (Reka & Memeti, 2024).

Regional Context and Research Gap

The Western Balkans provide a distinct context shaped by post-socialist institutional legacies and ongoing European integration processes. While countries in the region have made progress in adopting gender equality frameworks, implementation challenges remain significant (Ferati et al., 2023).

In North Macedonia, existing research highlights a pattern of strong formal commitment combined with limited institutional capacity. Policies are often comprehensive in design but constrained in practice by weak coordination, limited resources, and insufficient monitoring mechanisms (Reka & Memeti, 2024). Comparative studies from other European contexts suggest that such implementation gaps reflect broader structural dynamics rather than isolated national issues (Šebová et al., 2025).

Despite a growing body of literature on gender equality and Europeanization, important gaps remain. First, relatively few studies examine the implementation of gender

equality policies within specific sectors such as STEM. Second, existing research often treats institutional and socio-cultural factors separately, without fully capturing their interaction. Third, empirical research on the Western Balkans remains limited.

This study addresses these gaps by providing an integrated analysis of policy adoption, institutional capacity, and socio-cultural dynamics in North Macedonia's STEM sector. By combining insights from Europeanization and feminist institutionalism with empirical evidence, it contributes to a more comprehensive understanding of the relationship between formal policy alignment and substantive outcomes.

METHODOLOGY

This study employs a concurrent mixed-methods design to examine the gap between the formal adoption of gender equality policies and their substantive outcomes in North Macedonia's STEM sector. By integrating qualitative institutional analysis with quantitative trend data, the study captures both the structural patterns and the underlying mechanisms through which policy implementation gaps emerge and persist. The research is grounded in an interpretivist institutionalist perspective and adopts a single-case study design, which is particularly appropriate for examining how internationally promoted gender equality norms are translated into domestic institutional contexts.

North Macedonia represents a critical case for investigating implementation dynamics because it exhibits a high degree of formal alignment with European Union gender equality frameworks while continuing to experience persistent gender disparities within STEM education and employment. This combination makes it possible to explore the relationship between policy adoption and practical outcomes in a context characterized by substantial normative convergence but uneven implementation.

The analysis draws upon three complementary sources of evidence. First, a qualitative policy analysis was conducted through a systematic review of national legislation, strategic documents, action plans, and international commitments related to gender equality and STEM. Particular attention was given to policy objectives, implementation instruments, monitoring mechanisms, and areas of institutional coherence or fragmentation. Documents examined included national gender equality strategies, education policies, labour market initiatives, and commitments derived from international frameworks such as the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) and the Beijing Platform for Action.

Second, secondary quantitative data were collected from Eurostat and the State Statistical Office of the Republic of North Macedonia for the period 2015–2024. These datasets provide longitudinal indicators of gender disparities in STEM education and labour market participation, including tertiary enrolment, graduation rates, employment patterns, and human resources in science and technology (HRST) indicators. The use of Eurostat and SSO data ensures methodological consistency and cross-national comparability because both systems rely on harmonized statistical classifications and standardized definitions of STEM-related educational and occupational categories.

To examine the extent of attrition between educational attainment and labour market participation, the study operationalizes the concept of the "leaky pipeline" through a transition-rate indicator calculated as the ratio of employment share to educational share ($\text{Employment Share} / \text{Education Share}$). Rather than serving as a causal measure, this indicator functions as a diagnostic tool for assessing the conversion efficiency of the STEM pipeline. The indicator should therefore be interpreted as an aggregate measure of relative

conversion between educational attainment and labour market participation rather than as evidence of individual-level career transitions. Unlike enrolment or graduation statistics alone, transition rates identify the stage at which disparities become most pronounced by measuring the extent to which educational attainment is translated into professional participation. Consequently, the indicator helps locate where pipeline leakage occurs most severely at the interface between qualification and labour market entry. Nevertheless, this measure has limitations. It does not capture horizontal career mobility, such as STEM graduates moving into management or other professional sectors outside STEM occupations, nor does it track individual career trajectories over time. Future research could address these limitations through longitudinal individual-level datasets that allow for a more comprehensive analysis of career progression.

Third, primary qualitative data were generated through semi-structured interviews with 21 stakeholders. A purposive sampling strategy was employed to identify information-rich participants possessing direct knowledge of gender equality policy design, implementation, or professional practice within STEM fields. The sample was intentionally structured to capture perspectives from three interconnected levels of the policy ecosystem: policymakers responsible for policy design and implementation within relevant ministries ($n = 7$), representatives from higher education institutions involved in STEM training and academic governance ($n = 8$), and STEM professionals working in technical sectors ($n = 6$). This sampling approach enabled the study to examine how implementation challenges are perceived across multiple institutional contexts.

The final sample size was determined by thematic saturation, defined as the point at which additional interviews no longer generated substantively new themes, categories, or explanations regarding the implementation gap between policy commitments and practical outcomes. Interviews lasted approximately 40–45 minutes, were conducted with informed consent, and were transcribed verbatim for analysis.

Qualitative data were analysed using reflexive thematic analysis following Braun and Clarke's (2006) six-phase framework. The analytical process involved repeated familiarization with the data, systematic coding of meaningful segments, generation of preliminary themes, iterative review and refinement of themes, definition and naming of thematic categories, and final reporting of findings. Analysis was supported by NVivo 14 software, which facilitated the systematic organization of data and the maintenance of an audit trail documenting coding decisions, theme development, and analytical reflections throughout the research process.

Analytical rigor was enhanced through several complementary strategies. First, reflexive engagement with the data encouraged continuous examination of interpretive assumptions and analytical decisions throughout the coding process. Throughout the analysis, reflexive memos were maintained to document analytical assumptions and reduce the influence of researcher preconceptions on theme development. Second, methodological triangulation was employed by systematically comparing evidence from policy documents, statistical indicators, and stakeholder interviews. Quantitative trends identified through Eurostat and State Statistical Office datasets were cross-referenced with stakeholder accounts to assess convergence and divergence across data sources. This triangulation strengthened the credibility of the findings and reduced the likelihood that conclusions were driven by a single source of evidence.

The study adheres to established ethical research standards. All participants provided informed consent prior to participation. Anonymity and confidentiality were protected

through data anonymization procedures and secure data storage practices. Data were used exclusively for academic research purposes.

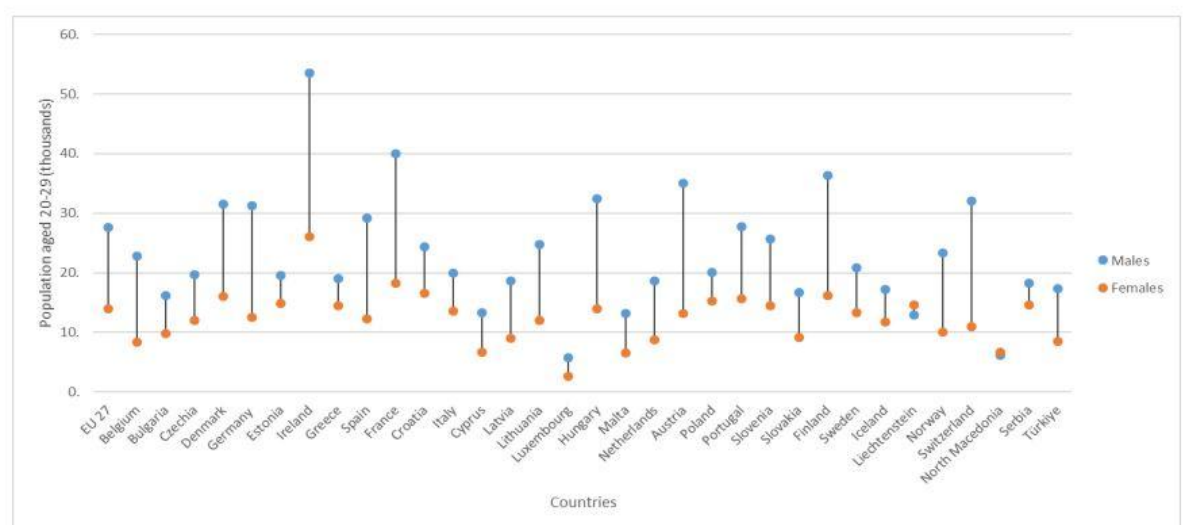
While the mixed-methods design and triangulation strategy strengthen the robustness of the findings, certain limitations should be acknowledged. As a single-case study, the findings are not intended to be statistically generalizable beyond North Macedonia. Rather, the study seeks analytical generalization by contributing to broader theoretical debates concerning Europeanization, feminist institutionalism, and gender equality policy implementation. Comparative research across other Western Balkan and European contexts could further evaluate the applicability of the findings and the transition-rate framework proposed in this study. In addition, the qualitative findings reflect stakeholder perceptions and should not be interpreted as direct measures of institutional effectiveness.

RESULTS AND ANALYSIS

This section integrates policy analysis, longitudinal indicators, and stakeholder evidence to explain the persistence of gender inequality in North Macedonia's STEM sector. The findings point not to a simple mismatch between policy and outcomes, but to a systematic and patterned decoupling between formal commitments and substantive change. Consistent with Europeanization theory, formal alignment with international standards coexists with limited transformation in practice, reflecting the interaction of institutional capacity, governance fragmentation, and socio-cultural norms.

The Education-Employment Paradox.

Figure 1: STEM graduates, by gender (2020)



Own calculations based on Eurostat data, at: https://ec.europa.eu/eurostat/databrowser/view/EDUC_UOE_GRAD04__custom_4163518/default/table?lang=en

As illustrated in Figure 1, North Macedonia exhibits a unique pattern compared to the EU-27 average. While many European states struggle with significant gender disparities at the tertiary graduation level, the gap in North Macedonia is notably narrow, with female STEM graduation rates nearly par with their male counterparts per 1,000 population. This data confirms that the 'human endowment' phase of the pipeline is relatively functional (World Bank et al., 2024).

However, this academic parity creates a starker contrast with labor market outcomes. The fact that such a high proportion of women graduate in STEM, yet the transition rate remains low (0.83) and the 'reproductive penalty' results in an 18.5% unemployment rate for qualified women, suggests the presence of significant structural barriers affecting labour market entry (Erturhan Işkın, 2024; Reka & Memeti, 2024). The 'leak' in the Macedonian pipeline does not occur in the classroom, but at the point of labor market entry, where formal educational success meets the informal barriers of a male-coded professional environment (Hanappi-Egger, 2013; Petreski & Pehkonen, 2023)

Formal Alignment without Effective Implementation

The analysis confirms that North Macedonia has achieved a high degree of formal alignment with international and European gender equality frameworks, including obligations derived from CEDAW and EU directives. However, this alignment remains largely procedural. Policy frameworks articulate broad commitments but rarely specify operational instruments, such as dedicated funding streams, measurable performance indicators, or enforcement mechanisms.

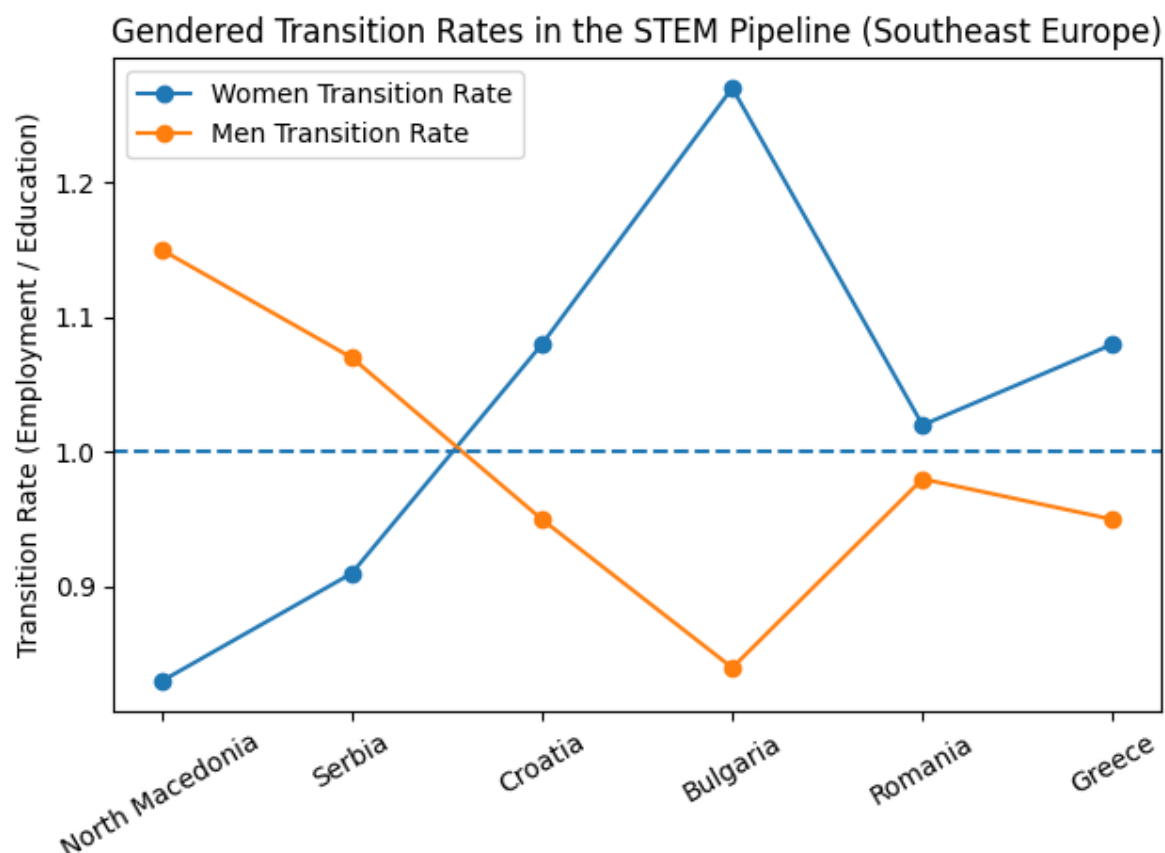
In practice, gender equality policies function primarily as compliance-oriented instruments, embedded in reporting requirements rather than decision-making processes. This pattern reflects what the Europeanization literature describes as “shallow compliance,” where rule adoption is decoupled from effective application. While aggregate indicators suggest incremental progress, these gains are uneven and do not translate into structural change within STEM fields. The result is a form of policy presence without policy effect, in which formal adoption does not alter institutional practices.

This dynamic is also reflected in stakeholder perceptions of implementation. As one policymaker noted, “On paper, everything is aligned with EU standards, but in practice there is no clear responsibility for who ensures these measures are actually carried out” (Interviewee 1, policymaker, 2025). This observation underscores the gap between formal adoption and operational accountability, reinforcing the characterization of gender equality policies as procedurally compliant but weakly enforced.

The Leaky Pipeline as a Measurable Structural Process

To move beyond descriptive accounts, this study operationalizes the “leaky pipeline” through transition rates between STEM education and employment, calculated as the ratio of employment shares to educational attainment. This allows for a more precise identification of where attrition occurs.

Table 1: Gender distribution and transition dynamics in the STEM pipeline in Southeast Europe



The results reveal systematic gender asymmetries across the region. While women approach parity in STEM education, their transition into employment remains uneven. In North Macedonia, for example, the transition rate for women (0.83) is substantially lower than for men (1.15), indicating a significant point of attrition between education and labor market entry. Similar, though less pronounced, patterns are observed in Serbia, while other countries (e.g., Bulgaria) exhibit partial reversals.

This evidence refines the conventional “leaky pipeline” model in two important ways. First, leakage is not confined to a single stage but occurs as a multi-stage filtering process, beginning with field-of-study segregation and intensifying during labor market entry. Second, the asymmetry between male and female transition rates demonstrates that attrition is not gender-neutral but structurally patterned.

Crucially, these findings challenge explanations based on individual preferences or capabilities. Women’s strong representation in tertiary education and their persistence into advanced study indicate that those entering STEM pathways are highly qualified. The divergence at the transition stage therefore reflects institutional and structural constraints, rather than differences in aptitude.

Governance Constraints and the Data-to-Policy Gap

Institutional analysis reveals that governance capacity acts as a primary bottleneck, transforming gender equality mandates into “empty shells” that lack substantive impact (Димитрова, 2010). In North Macedonia, responsibilities for gender equality in STEM are

distributed across a fragmented landscape involving the Ministry of Education and Science, the Ministry of Social Policy, Demographics and Youth, and various agencies (Reka & Memeti, 2024). This lack of a central coordinating authority ensures that policy execution remains horizontal and siled, rather than integrated into the core technical and economic agendas of the state. The qualitative data confirms that this structural fragmentation leads to a crisis of accountability. As one policymaker observed:

“On paper, everything is aligned with EU standards, but in practice there is no clear responsibility for who ensures these measures are actually carried out” (Interviewee 1, policymaker, 2025).

This highlights a core tenet of Feminist Institutionalism: the "decoupling" of formal rules from the informal, male-dominated organizational cultures that actually govern STEM institutions (Acker, 1990; Mackay et al., 2010). While North Macedonia has successfully adopted EU-aligned legal frameworks, the operational enforcement remains weak because no single institution is empowered or incentivized to bridge the gap between policy design and labor market reality.

This institutional inertia is compounded by a significant data-to-policy gap. While gender-disaggregated data are increasingly available, they are rarely operationalized to inform targeted interventions or budgetary allocations (Reka & Memeti, 2024). As one higher education representative noted, "We collect a great deal of data, but very little of it is systematically used when policies or institutional priorities are decided" (Interviewee 2, higher education representative, 2025). Monitoring frameworks often focus on simple participation counts rather than the structural barriers that lead to evidence of substantial female attrition in some STEM pathways (Reka & Memeti, 2024; European Commission, 2021). Ultimately, performance indicators remain weakly linked to long-term objectives, such as closing the 18.5% unemployment gap for qualified women (Reka & Memeti, 2024).

This dynamic creates a classic Type III error in implementation science: evaluating a policy as ineffective when, in reality, it has never been fully or faithfully implemented (Chriqui et al., 2023). In the Macedonian context, the persistent gender disparities in high-growth fields like ICT are not necessarily evidence of policy failure, but rather of a failure in institutionalization. Without a mandate to move beyond procedural compliance, these policies remain "symbolically adopted" yet operationally dormant.

Socio-Cultural Norms and Informal Institutional Effects

Beyond formal governance structures, socio-cultural norms play a critical role in sustaining gender disparities. Technical fields such as engineering and ICT continue to be associated with masculine identities, shaping both educational choices and professional trajectories.

The concept of “ambient belonging” is particularly relevant in this context. Qualitative evidence suggests that women encounter subtle signals of exclusion within technical environments, affecting both entry and retention. These socio-cultural dynamics are further reinforced through everyday institutional practices. As one STEM professional observed, “Even when women enter these fields, they often feel like outsiders. It is not explicit discrimination, but the environment is not designed with them in mind” (Interviewee 3, STEM professional, 2025). Such insights highlight how informal norms and workplace cultures can subtly discourage participation and retention, despite the presence of formal equality measures.

At the same time, reliance on aggregate indicators can obscure these inequalities. High levels of female participation in tertiary education are often interpreted as evidence of progress, reducing attention to disciplinary segregation and labor market disparities. This reinforces a perception of success that masks underlying structural imbalances, particularly in high-growth STEM sectors.

Synthesis: A Multi-Layered Implementation Gap

Taken together, the findings indicate that the implementation gap in gender equality is not a single failure point, but a multi-layered process involving four interrelated dimensions.

First, a formal–operational gap, where policies exist without the instruments required for effective implementation. Second, an institutional gap, characterized by fragmented governance and weak coordination. Third, a data-to-policy gap, where available evidence is not translated into actionable policy. Fourth, a socio-cultural gap, rooted in persistent norms and informal institutional practices.

These dimensions are mutually reinforcing. The absence of coordination limits the use of data; weak data systems hinder accountability; and socio-cultural norms reduce the effectiveness of formal interventions. Together, they produce a stable equilibrium in which formal alignment is decoupled from substantive outcomes.

From a theoretical perspective, the findings support the argument that Europeanization can produce formal compliance without transformation, while feminist institutionalism explains the persistence of gendered structures within organizations. Empirically, the transition-rate analysis provides a measurable indicator of this dynamic, demonstrating how structural barriers manifest at critical points in the STEM pipeline.

Overall, improving gender equality in STEM requires moving beyond policy adoption toward a more integrated approach that simultaneously addresses institutional capacity, governance structures, and socio-cultural dynamics.

DISCUSSION AND CONTRIBUTION

Bridging Norm Adoption and Institutional Reality

The findings demonstrate that the implementation gap in gender equality in STEM cannot be reduced to a technical failure of policy design. Rather, it reflects a systemic decoupling between externally driven norm adoption and domestic institutional realities. This distinction is analytically important because it shifts the focus from improving legislation to understanding the conditions under which policies acquire or fail to acquire operational force.

Consistent with Europeanization theory, North Macedonia has adopted the formal architecture of gender equality, including legislative provisions, national strategies, and alignment with European Union frameworks such as Horizon Europe. However, this alignment remains largely procedural. Policies are incorporated into formal documents and reporting cycles without being translated into the operational instruments such as dedicated funding, measurable targets, and enforcement mechanisms required for implementation. The result is a persistent condition of “policy presence without policy effect,” in which formal compliance coexists with limited institutional transformation.

The transition-rate analysis presented in Table 1 provides quantitative substantiation of this dynamic. Despite near parity in STEM education, women’s transition into employment remains structurally constrained. In North Macedonia, the transition rate for women (0.83) is markedly lower than for men (1.15), indicating a systematic divergence at

the point where formal equality should translate into labor market outcomes. This empirical pattern reinforces the argument that Europeanization has produced formal convergence without functional equivalence, consistent with accounts of “shallow” norm diffusion in accession contexts (Schimmelfennig & Sedelmeier, 2005; Noutcheva, 2012).

Informal Institutions and the Limits of Formal Policy

The persistence of gender disparities in STEM cannot be fully understood through limitations in formal policy design alone. Drawing on feminist institutionalism, the findings point to the critical role of informal institutions including organizational cultures, implicit norms, and gendered power relations in shaping both opportunities and outcomes (Acker, 1990; Mackay et al., 2010). These informal dimensions operate alongside formal rules but often undermine their intended effects.

The concept of ambient belonging provides a useful lens for interpreting these dynamics. Evidence from stakeholder interviews suggests that women in technical fields frequently encounter subtle yet persistent signals of exclusion that influence both their entry into and retention within STEM careers. As one respondent noted, “It is not that women are told directly that they do not belong, but there is a constant sense that you have to prove yourself more than others, especially in technical environments” (Interviewee 3, STEM professional, 2025). Such experiences are rarely captured by formal policy frameworks, which tend to prioritize access and participation while overlooking issues of inclusion and institutional climate.

The interaction between formal and informal institutions helps explain a central empirical puzzle: why women who perform strongly in education do not transition into STEM employment at comparable rates. The transition-rate asymmetry identified in Table 1 indicates that institutional filtering mechanisms are particularly pronounced at the interface between education and the labor market. At this stage, formal equality measures are often weakest, while informal practices such as hiring norms, workplace cultures, and gendered expectations exert a stronger influence.

This interpretation aligns with the concept of policy displacement, whereby gender equality is formally endorsed while the underlying conditions that reproduce inequality remain largely unchanged (Verloo, 2005). From this perspective, the limitations of current policy approaches lie not only in their design but also in their limited engagement with the informal institutional environment in which they are implemented.

Reinterpreting the “Leaky Pipeline”

The results both confirm and extend the “leaky pipeline” framework. While the data support the existence of cumulative attrition, the transition-rate analysis suggests that leakage is neither uniform nor random. Instead, it is structured across multiple transition points, each associated with distinct institutional and socio-cultural constraints.

In particular, the findings indicate that the transition from education to employment represents a critical bottleneck. While women achieve near parity in educational attainment, their representation declines sharply at labor market entry, as evidenced by transition rates below unity. This pattern challenges supply-side explanations that focus on increasing female participation in STEM education. Instead, it points to demand-side constraints, including recruitment practices, professional networks, and organizational cultures.

Moreover, cross-country comparison in Table 1 demonstrates that these patterns are not uniform across the region. Variation in transition rates suggests that institutional

configurations mediate the extent of pipeline leakage, reinforcing the argument that gender inequality in STEM is context-dependent rather than structurally inevitable.

Taken together, these findings suggest that the “leaky pipeline” should be reconceptualized not as a linear process of attrition, but as a multi-stage system of institutional filtering, where inequalities are reproduced through the interaction of formal structures and informal practices.

Theoretical Contributions

This study contributes to the literature in three key ways.

First, it advances Europeanization theory by providing sector-specific evidence that formal compliance does not necessarily translate into substantive outcomes. By introducing transition rates as an empirical indicator, the study demonstrates how the gap between rule adoption and rule application can be measured within a specific policy domain.

Second, it contributes to feminist institutionalism by empirically illustrating how formal and informal institutions interact to reproduce gender inequality. The findings show that even well-designed policies are constrained by embedded organizational norms, reinforcing the concept of institutional “stickiness.”

Third, the study proposes the concept of a multi-layered implementation gap, encompassing four interrelated dimensions:

- (1) formal–operational,
- (2) institutional,
- (3) data-to-policy, and
- (4) socio-cultural.

This framework extends existing approaches by integrating insights that are often treated separately, offering a more comprehensive explanation of why policy interventions fail to achieve intended outcomes.

In addition, the application of the Type III error framework (Chriqui et al., 2023) provides an important conceptual clarification. The findings suggest that gender equality policies in North Macedonia may be mischaracterized as ineffective when, in reality, they have not been implemented with sufficient intensity or coherence to produce measurable effects.

Policy Implications

From a policy perspective, the findings challenge incremental approaches to reform. Adjustments limited to formal frameworks such as expanding strategy documents or improving reporting mechanisms are unlikely to disrupt the structural conditions underpinning the implementation gap.

Instead, effective intervention requires a systemic approach that simultaneously addresses all four dimensions identified in this study. This includes:

- Strengthening operational instruments, such as funding mechanisms and performance indicators
- Improving institutional coordination and accountability structures
- Establishing a specific "National STEM Gender Taskforce" that bridges the Ministry of Education and the Ministry of Social Policy
- Embedding data-driven decision-making within policy processes

- Addressing socio-cultural norms and organizational practices that shape participation and advancement

These dimensions are interdependent. Progress in one area is likely to be constrained if others remain unaddressed. As such, gender equality in STEM should be understood not as a discrete policy objective, but as a cross-cutting governance challenge requiring coordinated institutional and cultural change.

CONCLUSION AND POLICY RECOMMENDATIONS

This study set out to explain why strong formal commitments to gender equality in North Macedonia have not translated into comparable outcomes in STEM education and employment. The findings demonstrate that this disconnect cannot be attributed solely to deficiencies in policy design or to individual-level participation patterns. Rather, it reflects a systemic and multi-layered implementation gap, produced through the interaction of four mutually reinforcing dynamics: limited operationalization of formal commitments, fragmented governance structures, weak integration of gender-disaggregated data into policymaking, and persistent socio-cultural norms that shape participation in technical fields.

Empirically, the study advances this argument by operationalizing the “leaky pipeline” through transition rates between education and employment. The results show that, despite near parity in STEM education, women in North Macedonia experience a significantly lower transition into employment compared to men. This asymmetry provides measurable evidence that the primary barrier lies not at the point of access to education, but at the interface between qualification and labour market entry. In this sense, the findings shift the analytical focus from participation to conversion, highlighting the institutional and structural conditions that determine whether educational attainment translates into economic outcomes.

At the theoretical level, the study contributes to the literature by demonstrating that the gap between policy adoption and outcomes is not a singular implementation failure but a compound process of institutional decoupling. While Europeanization explains the adoption of formal frameworks, feminist institutionalism helps account for their limited impact by revealing how gendered norms and organizational practices persist within institutions. The concept of a multi-layered implementation gap developed here integrates these perspectives, offering a more comprehensive explanation of why formal alignment does not yield substantive equality.

From a policy perspective, the findings suggest that the central challenge is no longer the adoption of gender equality frameworks, but their translation into effective institutional practice. Incremental adjustments to existing policies are unlikely to produce meaningful change if they do not address the structural conditions identified in this study. Instead, a more systemic approach is required.

First, policy interventions should prioritize sector-specific instruments, particularly in ICT and engineering, where gender disparities are most pronounced. General equality frameworks are insufficient to address the distinct barriers present in these fields.

Second, strengthening institutional coordination and accountability is essential. The fragmentation of responsibilities across ministries and agencies limits policy coherence and weakens implementation capacity. Establishing clearer mandates and coordination mechanisms would improve consistency and effectiveness.

Third, greater emphasis should be placed on data-driven policymaking. Existing gender-disaggregated data must be systematically integrated into policy design, monitoring, and evaluation processes. This would help ensure that disparities within STEM fields are identified and addressed, rather than obscured by aggregate indicators.

Fourth, policy efforts should extend beyond access to address transition and retention dynamics. This includes targeted support at the education-to-employment interface, such as internships, mentorship programs, and measures to reduce barriers in recruitment and early career progression.

Implementation Gap Layers

Layer	Primary Barrier Identified	Suggested Action
Formal-Operational	Policies lack funding and clear performance indicators.	Link gender objectives to budgetary allocations.
Institutional	Fragmented responsibilities across ministries.	Establish a central coordinating body for STEM equality.
Data-to-Policy	Disaggregated data exists but isn't used for design.	Mandate gender-impact assessments for new STEM investments.
Socio-Cultural	"Ambient belonging" and masculine stereotypes.	Targeted mentorship and institutional culture shifts.

Finally, institutional reforms must be complemented by interventions targeting socio-cultural norms and organizational practices. Without addressing the informal dimensions of exclusion such as workplace culture, professional networks, and perceptions of belonging formal equality measures are unlikely to achieve sustained impact.

Taken together, these findings suggest that advancing gender equality in STEM requires a shift from declarative compliance to embedded implementation. Closing the gap between formal commitments and substantive outcomes depends on aligning policy instruments, institutional capacity, and socio-cultural change within a coherent framework. In this respect, gender equality in STEM should be understood not only as a question of social justice, but as a core issue of governance effectiveness and economic development, particularly in the context of an increasingly knowledge-based and digital economy.

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Appendix

Table A1

Overview of Thematic Coding Structure and Illustrative Evidence

Theme	Sub-theme / Code	Description	Illustrative Quote	Data Source
Formal Operational Gap	Policy practice disconnect	Misalignment between formal policy adoption and implementation mechanisms	“On paper, everything is aligned with EU standards, but in practice there is no clear responsibility for who ensures these measures are actually carried out.”	Interviewee 1 (policymaker, 2025)
	Weak enforcement mechanisms	Lack of monitoring, accountability, and implementation tools	“Strategies exist, but there are no concrete mechanisms to follow up or measure impact.”	Interviewee 2 (policy advisor, 2025)
Institutional Gap	Fragmented governance	Lack of coordination across ministries and institutions	“Different ministries are working on related issues, but there is very little coordination, so initiatives remain isolated.”	Interviewee 5 (higher education administrator, 2025)
	Donor dependency	Reliance on external funding for gender equality initiatives	“Many initiatives depend on short-term projects, which makes continuity very difficult.”	Interviewee 4 (NGO expert, 2025)
Data-to-Policy Gap	Underutilized data	Limited use of statistical data in policy design	“We collect data, but it is rarely used to shape actual policies or interventions.”	Interviewee 6 (statistical office expert, 2025)
	Lack of gender-disaggregated indicators	Absence of detailed monitoring tools for STEM sectors	“There is no consistent tracking of women’s progression from education into employment.”	Interviewee 2 (policy advisor, 2025)
Socio-Cultural Gap	Gender norms and stereotypes	Cultural perceptions of STEM as male-dominated fields	“Technology is still seen as a male field, which discourages girls from pursuing it early on.”	Interviewee 7 (educator, 2025)
	Ambient belonging / exclusion	Subtle signals of non-belonging in STEM environments	“It is not direct discrimination, but you feel like you do not fully belong.”	Interviewee 3 (STEM professional, 2025)
Leaky Pipeline Dynamics	Transition barriers	Drop-off between education and labor market entry	“Many women graduate in STEM, but they struggle to find jobs in their field.”	Interviewee 3 (STEM professional, 2025)
	Selective persistence	Retention of a small subgroup at advanced levels	“Only the most determined women continue to PhD level; many leave earlier.”	Interviewee 5 (higher education administrator, 2025)

Interview Sample (Detailed Roles)**Policymakers (n=7)**

Ministry of Education and Science:

- Head of Sector for Higher Education
- Head of Sector for Science, Innovation and Technology
- Director, Bureau for Development of Education

Ministry of Social Policy, Demography and Youth:

- Head of Sector for Equal Opportunities
- National Coordinator for Gender Equality
- Head of Sector for Labour Market Policies / Employment

EU Integration / Cross-cutting roles:

- Advisor on EU Acquis (Chapter 19 – Social Policy and Employment)
- Gender Equality Coordinators within line ministries

Higher Education Representatives (n=8)

Academic staff (professors and teaching staff) from:

- South East European University (SEEU)
- Ss. Cyril and Methodius University in Skopje (UKIM)
- Mother Teresa University (UT)
- “St. Kliment Ohridski” University – Bitola (NT)

STEM Professionals (n=6)

Practitioners from private and public sectors, including:

- Software engineers and IT specialists
- Engineers in technical fields (e.g., industrial, electrical, civil)
- Public sector technical staff (e.g., IT or engineering roles in state institutions)

LaTeX table source (Table 1) in the appendix

<code>\begin{table}[htbp]</code>
<code>\centering</code>
<code>\caption{Gender distribution and transition dynamics in the STEM pipeline in Southeast Europe (\%)}</code>
<code>\label{tab:stem_pipeline_transition}</code>
<code>\begin{tabular}{lccccccc}</code>
<code>\toprule</code>
<code>& \multicolumn{2}{c}{Education}</code>
<code>& \multicolumn{2}{c}{Employment}</code>
<code>& \multicolumn{2}{c}{Academic career}</code>

Transition rate (E $\rightarrow$ Em) \\	
\\cmidrule(lr){2-3} \\cmidrule(lr){4-5} \\cmidrule(lr){6-7} \\cmidrule(lr){8-9}	
Country	
& W & M	
& W & M	
& W & M	
& W & M \\	
\\midrule	
North Macedonia & 48 & 52 & 40 & 60 & 25 & 75 & 0.83 & 1.15 \\	
Serbia & 44 & 56 & 40 & 60 & 27 & 73 & 0.91 & 1.07 \\	
Croatia & 38 & 62 & 41 & 59 & 26 & 74 & 1.08 & 0.95 \\	
Bulgaria & 37 & 63 & 47 & 53 & 28 & 72 & 1.27 & 0.84 \\	
Romania & 42 & 58 & 43 & 57 & 24 & 76 & 1.02 & 0.98 \\	
Greece & 36 & 64 & 39 & 61 & 23 & 77 & 1.08 & 0.95 \\	
\\bottomrule	
\\end{tabular}	
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\\begin{minipage}{0.92\\textwidth}	
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\\textit{Notes:} Transition rate is calculated as the ratio of employment share to education share (Employment / Education). Values below 1 indicate attrition ("leakage") between education and employment, while values above 1 indicate relative gains. Data are harmonized from Eurostat tertiary education statistics, HRST datasets (scientists and engineers), and She Figures indicators on senior academic positions (latest available data, 2023--2025).	
\\textit{Sources:} Eurostat (2024, 2025); European Commission, She Figures; UNDP (2022).	
\\end{minipage}	
\\end{table}	