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The Persistence of Gender Inequality in e-Science: The Case of eSec

Öznur Karakaş[1,2]

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Abstract E-science, or networked, collaborative and multidisciplinary scientific research on a shared e-infrastructure using computational tools, methods and applications, has also brought about new networked organizational forms in the transition of higher education towards the entrepreneurial academy. While the under-representation of women in ICTs is well-recorded, it is also known that the potential of new organizational forms such as networked structures to promote gender equality remains ambiguous, as they tend to perpetuate already existing inequalities due to their embeddedness in larger and longer-term structural or institutional gender effects. Based on a year-long ethnographic study in a networked academic e-science collaboration in Sweden and 45 in-depth, semi-structured interviews with its affiliated researchers, this article analyzes the multi-level obstacles to achieving gender equality in e-science to highlight the ways in which gendered disparities persist in this new, project-based academic networked organization in Sweden, hereafter called eSec. At the *organizational level* eSec remains deeply embedded in the traditional disciplinary and institutional academic setting, inadvertently reproducing existing gender imbalances across sciences. Furthermore, as a project-based organization, it is also embedded in the shift towards an entrepreneurial university model driven by new managerialism, the latter having a well-documented adverse effect in gender equality. This represents *a structural-level* obstacle which leads to especially female junior faculty leaving academy for industry. An *individual level* obstacle is

The name of the organization is pseudonymized to maintain its confidentiality.

✉ Öznur Karakaş
oznur.karakas@ntnu.no

[1] Center for Gender Research, Uppsala University, Uppsala, Sweden

[2] Interdisciplinary Studies of Culture (KULT), Norwegian University of Science and Technology, Trondheim, Norway

observed alongside these as disavowal (*Verleugnung*) of gender disparities, an affect identified as a key mechanism of subjectivation in neoliberalism.

Keywords Project-based networked organizations · e-Infrastructure · Gender equality · New managerialism · Disavowal

Introduction

The term "e-science," introduced by John Taylor, Director General of Research Centers in the UK, in 1999, encompasses the development and utilization of high-performance computing tools to facilitate collaborative, multidisciplinary research (Hine 2006: vi; Schroeder and Fry 2007: 563) involved in working with very large data sets on distributed network or grid systems. The terms e-science, cyberinfrastructure, e-infrastructure (Ribes and Lee 2010: 231), as well as grid computing, collaboratories (Lee et al. 2008: 1; Jankowski 2007: 549) and cyberscience (Nentwich 2003) are at times used interchangeably to refer to the technological mediation in sciences within larger distributed and multidisciplinary networks supported by ICTs.

Science and technology studies (STS) have extensively explored various facets of e-science, encompassing the adoption of e-science tools by academic researchers (Pearce 2010), social science approaches to e-science (Schroeder and Fry 2007), and disciplinary variances in e-science adoption (Merz 2006; Wouters and Beaulieu 2007). Their engagement extends to developing ethnographic methods for analyzing co-location in scientific research enabled by grid systems (Beaulieu 2010), as well as studying both the use of case studies for the exploration of e-science (Beaulieu et al. 2007) and potential new scientific practices on communication networks (Hine 2007). They have been cautious about techno-optimistic narratives regarding the transformative impact of e-science (Hine 2007), sometimes dubbed "the fourth paradigm" (Hey et al. 2009); have questioned the novelty of technologies involved in e-science (Elvebakk 2006) and advocated for "critical accountability" amid hope and hype (Wouters and Beaulieu 2007)[1]. They emphasize complementing technical capabilities "with an in-depth understanding of social processes and consequences" (Hine 2006: ix). A notable concern within this context is the position of women in science(s) with the advent of this new technology (Kretschmer and Aguillo 2005).

The persistent under-representation of women in ICT fields is well documented (Gillard et al. 2010; Ceci et al. 2014; Vitores and Gil-Juarez 2016; Cheryan et al. 2017; Sax et al. 2017; Michell 2017; Zacharias et al. 2020). *The European Parliament Report on Education and Employment of Women in Science, Technology and the Digital Economy* highlights that "the percentage of women in ICT careers still remains relatively low, and it is currently below 2% of women's total share in

[1] Wouters and Beaulieu (2007) prefer the term *e-research* over that of *e-science* to avoid the common overemphasis in the literature on computational or quantitative analysis, and to better take into consideration disciplinary differences in the integration of e-infrastructures and computational tools in research.

the European labor market" (Zacharias et al. 2020: 14), with Scandinavian countries notably affected.

The *Telenor Report on the Gender Gap in Technology in Scandinavia* (2019) reveals that across 35 European countries, "only 1 in 5 computer science graduates are women." According to 2018 *OECD Gender Data Portal*, "the gender gap in Norway, Sweden and Denmark is particularly wide" (Telenor 2019: 9). *She Figures 2021* (European Commission, Directorate-General for Research and Innovation 2021) indicates a significant gender gap among doctoral graduates in ICTs in Sweden, with only 25.73% of the graduates being women in 2018, a statistic that has remained unchanged since 2015. The Nordic Gender Equality Paradox (Stoet and Geary 2018) is observed, where affluent northern European countries, despite advocating gender equality, display low representation of women in STEM fields, especially in physical sciences, mathematics, statistics, and ICTs (European Commission, Directorate-General for Research and Innovation 2021). This under-representation is often associated with vertical gender segregation, signifying the attrition of women as they progress along the career ladder (Nielsen 2017; Doerr 2022).

Literature indicates that women's engagement with ICTs may follow non-linear pathways not extensively recorded, extending beyond traditional computer science careers (Vitores and Gil-Juarez 2016). This underscores the importance of studying women's engagement with ICTs in diverse areas such as "art and design, cognitive sciences, new media, biology information science and education or library science" (2016: 673). E-science emerges as a potential non-linear career trajectory for women in ICTs, particularly as computational tool development for research purposes sits at the intersection of mathematics, statistics, and ICTs-areas where women are least represented in Sweden- with applications in other sciences, such as life sciences and environmental sciences, where women are better represented. It is thus a noteworthy area of research to track both the potential for and obstacles to the wider representation of women, given the increasing computationalization of scientific research this time under the rubric of data-driven sciences (Montáns et al. 2019). Despite extensive discourse on international collaboration and communication in e-science among researchers located at different geographical sites in a distributed virtual network, as well as computationally driven collection, representation, visualization, analysis and publication of very large data sets (Hine 2006, 2007; Jankowski 2007; Lee et al. 2008; Beaulieu 2010; Ribes and Lee 2010), both the emergence of new academic organizations and the associated gender dynamics within them remain understudied. This gap becomes particularly significant as "data, data objects and their infrastructures are involved in transforming the links between institutions and practice" (Alaimo 2021: 1091). A recent study on gender dynamics in e-science reports that the under-representation of women and existing horizontal gender segregation in sciences remain operative in e-science (Karakaş and Griffin 2023), emphasizing the need to analyze the reasons for the persistence of existing gender asymmetries in e-science. Against this backdrop, the article responds to the research questions, *what are the obstacles to achieving gender equality in e-science*, and *what are the mechanisms under which existing gender asymmetries in STEM fields remain operative in*

e-science drawing on year-long qualitative research within an interinstitutional networked e-science organization in Sweden[2].

The development of e-science in Sweden was promoted in 2010 pursuant to the Swedish Government's Bill on Research Policy which endorsed the advancement of e-science as a Strategic Research Area (SRA). The support for SRAs via external funding has its roots in earlier Swedish Government Bills, notably the one from 2008 aimed at enhancing research and innovation, a move considered by some as advancing towards new managerial management in higher education (Beach 2013). This Bill anticipated a significant boost in external funding by five billion Kronor from 2009 to 2012, distributed competitively, concurrent with a decrease in direct funding by 20–40% over the same duration (Beach 2013: 519). eSec was among the national interinstitutional networked academic organizations founded in this process through the collaborative efforts of Principal Investigators (PIs) from three distinguished Swedish universities with the external funding challenged towards e-science as an SRA. The scope of e-science within eSec encapsulates the development of computational methods and tools for scientific research purposes as well as their applications across a spectrum of domains, organized under the overarching, multidisciplinary fields of material sciences, life sciences and environmental sciences. Sciences associated with eSec coalesce around e-science projects that straddle the development of computational tools and their application across these domains, rendering eSec "a project-based networked organization" (Lindgren and Packendorff 2006; Manning 2010).

Research in feminist organization studies has examined the potential of such emergent organizational forms to promote gender equality. These new, networked organizational forms, characterized by flexibility and less hierarchical structures in contrast to the traditional bureaucratic models often linked with patriarchy, have at times been lauded for their potential to foster gender equality (Hebson and Grugulis 2004). However, subsequent empirical studies within feminist institutionalism (Mackay 2014; Chappel and Mackey 2017) and feminist organization studies (Hebson and Grugulis 2004; Lindgreen and Packendorff 2006; Benschop and Brouns 2003; Tildesley et al. 2022) have underscored the ambiguity of this potential. They rather reveal that such new organizational forms either perpetuate pre-existing disparities or engender new mechanisms of oppression (Gill 2011). This indicates a setting in which "newness" is nested in older equalities (Mackay 2014). Furthermore, the type of project-based networked organizations that eSec exemplifies are also situated within the general shift towards the entrepreneurial university marked by the projectification of academic work (Fowler et al. 2013) within the larger new managerialist governance of academia, whose negative impact on gender equality is well-recorded (see Acker and Wagner 2019, among others). Against the backdrop of these literatures which expand on Acker's analysis (1990, 1992) regarding the role of organizational mechanisms and cultures in the creation and perpetuation of gender inequalities; the article states that any inquiry on the obstacles to promoting gender equality in e-science, especially when it comes to the reasons for the perpetuation of existing

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gender inequalities, must be situated within the context of the embeddedness of new organizational forms through which e-science is practically enacted. While the limited potential of the new networked organizational forms to promote gender equality has been analyzed in various sectors, such as the new media (Gill 2011), the new project-based networked organizations established around e-science and data-driven sciences have thus far evaded scholarly attention. The research bridges this gap with a multi-level analysis on the obstacles to attaining gender equality in eSec in a way to reveal the underlying mechanisms for the perpetuation of gender inequalities therein.

The next section includes a discussion on the new organizational forms' potential for gender equality drawing on the above-mentioned literatures. The case study and the research methodology are then introduced in the subsequent section, followed by a discussion on the findings of the research which reveal obstacles to promoting the still prevailing gender equality ideal in the practical enactment of e-science in eSec at three intertwined levels: structural, organizational, and individual. The organizational level obstacle informs the ways in which the potential of newness in eSec remains non-operative due to its embeddedness in the larger institutional and disciplinary setting of academe. The structural level obstacle more specifically points towards the embeddedness of eSec in the transition towards new managerialism in higher education, known as "an organizational form of neoliberalism" (Lynch and Grummel 2018) whose negative repercussions for gender equality have been comprehensively analyzed (Ylijoki 2015; Gill 2017; Acker and Wagner 2019; Kuldova 2021; Mason and Megoran 2021; McKeown 2022). The individual level obstacle, on the other hand, highlights the mechanism through which this structural level obstacle remains operative in the case study at the subjective level in the form of disavowal.

New Organizational Forms and Gender

Academic e-science collaborations bring about new "networked organizational forms" (Dimitrova and Koku 2010; Dimitrova and Wellman 2015; Ying Mo 2016) in higher education in that they foster collaborative work at a distance between researchers of diverse disciplinary backgrounds on a shared e-infrastructure. Our case study, being one such networked organization, can further be classified as a project-based networked organization (Lindgren and Packendorff 2006; Manning 2010; Tukiainen and Granqvist 2016), as the work is organized around short-term projects realized through external funding. Examining gender equality in this setting in the domain of ICTs where the acute under-representation of women especially in Scandinavian countries is well-established (Gillard et al. 2010; Ceci et al. 2014; Vitores and Gil-Juarez 2016; Cheryan et al. 2017; Sax et al. 2017; Michell 2017; Telenor 2019; Zacharias et al. 2020; European Commission Directorate-General for Research and Innovation 2021), inevitably requires an inquiry into the newness and embeddedness of these organizational forms when it comes to gender equality.

These new organizational forms, also dubbed post-bureaucratic organizations (PBO) (Donnellon 1994) characterized by flexibility, less hierarchy and rigidity, were at times

greeted with a certain level of optimism regarding their potential to break away from the bureaucratic organization of work mostly associated with patriarchy (Hebson and Grugulis 2004). Yet, the literature on feminist institutionalism (Mackay 2014; Chappel and Mackay 2017) and feminist organization studies (Hebson and Grugulis 2004; Lindgreen and Packendorff 2006) has since largely recorded that the potential of new organizational forms, such as networks, to promote gender equality remains ambiguous, as these forms perpetuate already existing inequalities due to their embeddedness in larger structural or institutional gender effects (Benschop and Brouns 2003; Tildesley et al. 2022).

Hebson and Grugulis (2004) record that the restructuring of work mostly results in increasing the quantity of opportunities for women rather than their quality, flexibilization leading women to fill part-time, low-paid, and contingent positions. They thus state that the so-called 'feminization' of work surrounding networked forms of organization do not guarantee a positive change in gendered power relations. Although less hierarchy has helped women's progression into middle management positions, this has not necessarily been translated into rewards and future prospects (2004: 234). Similar findings are also observed in project-based networked organizations. Lindgren and Packendorff (2006) record that this type of work organization, rather than becoming a vector for positive change, reproduces masculine values of control, as "the failures of bureaucracies that led to the emergence of temporary forms of organizing ... are now used as arguments for splitting big projects into smaller and smaller ones in the eternal strive for total control" (2006: 861). Gill (2011) makes similar observations in relation to new media work characterized by both the perpetuation of old inequalities and the introduction of new forms of gender inequalities resulting from informality, autonomy, and flexibility. Chappel and Mackay (2017: 55), though underlining the potential of networks, as groups of actors, to be "the carrier of institutional effects", reveal that this effect is mostly observed in the form of clientelism or resistance against gender mainstreaming policies, such as gender quotas. Hence, the newness in these new organizational forms is rather nested in older inequalities (Mackay 2014) and they continue to act as informal institutions, non- official norms, rules, and conventions, either to perpetuate old inequalities or to resist positive change. In this article, I attest a similar nestedness in my case study. Below, I claim that this stems from eSec's organizational embeddedness in larger disciplinary, structural, and institutional "gender effects" (Gains and Lowndes 2014; Lowndes 2019), amplifying the structural obstacle to gender equality which results from the new managerial logic prevailing in the projectified higher education. Here, this logic corresponds to an affective atmosphere of disavowal which acts as a subtle resistance to gender equality and hinders the effective implementation of the still prevailing ideal of gender equality in Sweden.

Case Study and Methodology

Case Study

The e-science network eSec was founded in 2010 by Principal Investigators (PIs) from three prominent Swedish universities in response to the Swedish Government

Bill on Research Policy, which advocated for the promotion of e-science as a strategic research area (SRA). Strategic research areas (SRAs) typically operate as ad hoc networked organizational forms, distinct from the official academic management line. Notably, at University B[3], an SRA Collegium was established as a formally recognized organizational unit.

eSec operates under the governance of a program council, comprising of representatives from three universities and an industrial stakeholder. Oversight and coordination of eSec activities across the three universities, including budget allocation decisions, are managed by a dedicated management group. This group is composed of two coordinators from each university, with a chief coordinator from University A.

In terms of funding allocation, both University A and University C predominantly direct eSec funding towards recruiting contingent researchers who contribute to projects initiated by the original PIs who had applied for government funding to establish e-science as an SRA. Furthermore, University A has instituted a graduate school in collaboration with another SRA. In contrast, University B channels funding primarily into projects initiated through open calls, particularly when the original PIs have departed the organization.

eSec's primary focus revolves around e-science projects situated at the intersection of computational technology development and application areas within the domains of material science, life sciences, and environmental sciences. The development of computational technologies occurs in various departments, including the scientific computing division in University A, the two mathematics departments at University B, and the computing science department at University C. Researchers in the theoretical chemistry and physics departments at University A and B also contribute by developing their own computational methods.

Functioning as a national, interinstitutional project-based networked organization, eSec serves as a STEM-centered organizational unit (SOU). This positioning is contextualized within the broader transformation in higher education towards the new entrepreneurial university model (Foss and Gibson 2015; Warshaw 2021), recognized as a tool for the neoliberalization of higher education (Niska and Vesala 2021; Laalo et al. 2019).

Methodology

The article presents the results of a yearlong ethnographic fieldwork in the context of eSec, which serves as a case study. Case studies are "important elements in the epistemic landscape of STS," as they provide rich and contextualized data to oppose "claims of universality (i.e., the scientific method etc.)" (Beaulieau et al. 2007: 673). They hold particular importance in research that acknowledges the "disunity of sciences" (Galison and Stump 1996), emphasizing the need to investigate scientific fields as distinct epistemic cultures or sociomaterial assemblages that enact specific

[3] To maintain confidentiality in relation to the institutions studied, they have been given pseudonyms, i.e. A, B, C.

Table 1. Segregation of interviewees based on gender and academic status

Category	Total	Women	Men
Tenured faculty members	28	11	17
Contingent faculty members	17		
- PhD candidates	12	6	6
- Postdoctoral researchers	5	3	2

machineries of knowledge production, thereby shaping the diverse avenues through which knowledge in a given specific field is generated (Knorr-Cetina 1999). Laboratories, for instance, serve as *milieux* in which scientists are constructed as epistemic subjects through common practices around these machineries. Case studies, therefore, serve to highlight "diversity" of knowledge production practices, and "de-essentialize" science and technology (Beaulieau et al. 2007: 675). The existing gender disparities across sciences, as discussed in the introduction of this article, further underscore the disunity of sciences and reveal that scientific fields also exhibit distinct epistemic cultures in terms of the ways in which gender is performed. Consequently, the case study method is equally relevant for the examination of gender dynamics within and across sciences.

The data discussed in this article stem from participant observation of eSec activities conducted between September 2021–August 2022, 45 semi-structured in-depth interviews conducted in March 2022–May 2022 with 18 female and 27 male researchers affiliated with eSec, along with information shared on eSec official website, call for applications and annual reports. The interviews, with an average length of 60 min, covered topics such as the interviewees' educational background, their entry into eSec, their understanding of e-science, their collaborations with other researchers, their perspectives on the representation of women in their respective disciplines, e-science and eSec, their views on obstacles to gender equality, and measures to promote gender equality in e-science and their respective sciences. The interviewees encompassed contingent junior faculty predominantly composed of PhD candidates and postdoctoral researchers, as well as tenured senior faculty. Of the interviewees, 28 were tenured faculty members (11 women and 17 men), while 17 were contingent faculty members (12 PhD candidates -6 women and 6 men-, and 5 postdoctoral researchers -3 women and 2 men-) (Table 1).

They were purposively sampled and contacted via email. The membership structure of this ad hoc network was ambivalent. Researchers were deemed members of eSec firstly through their affiliation with certain divisions and departments (i.e., the scientific computing division in the department of IT at University A), secondly with the research groups of original PIs at University A and University C who receive direct funding from eSec, and thirdly through their engagement in projects funded by eSec through open calls (University B). I initially approached the female researchers affiliated with eSec at University B, the scientific computing program of the IT department of University A, and female researchers mentioned in the annual report of University C submitted to eSec in 2021. Subsequently, I approached all researchers on these lists, as well as PIs involved in computational

tool development within the network. The final group of 45 researchers comprised those who responded positively to the interview request. Interviews were conducted either online (30 interviews) or at University A (15 interviews).

The reliance on online interviews, as well as online participant observation, was crucial for studying networked eSec interactions. Given that e-science is characterized by virtual mediation, the concept of co-presence extends beyond physical co-location, acknowledging the significance of mediated settings as a means of achieving co-presence, without excluding face-to-face interactions (Beaulieau 2010). Co-presence, encompassing both online and offline engagement with the field and participants, is therefore pertinent for the study of knowledge production sites like e-science, which are not "tied to a physically defined space such as a lab" (Beaulieau 2010: 454).

> Co-presence decentralizes the notion of space without excluding it. It opens up the possibility that co-presence might be established through a variety of modes, physical co-location being one among others. Not only does it enable the researcher to take mediated settings very seriously (insofar as they are a means or resource for being co-present), but it also does not exclude face-to-face situation (Beauliau 2010: 454).

The research received ethical approval from the Swedish Ethical Review Authority (Etikprövningsmyndigheten, No. 2022-00276-01). Interviewed researchers were provided with project information sheets and gave written consent for the use of their pseudonymized data in publications.

In this study, a constructivist grounded theory approach, characterized by its abductive rather than inductive orientation (Bryant 2021), along with abductive data analysis (Timmermans and Tavory 2012; Tavory and Timmermans 2014), was employed to collect and analyze data. Grounded theory "is a general methodology, a way of thinking about and conceptualizing data" (Strauss and Corbin 1994: 275), which envisages theory formation or construction grounded in qualitative data (Charmaz 2014; Conlon et al. 2015; Bryant 2021). It encompasses open coding of qualitative data through an iterative move between data collection, data coding and memoing. This process allows for the development and refinement of concepts and theories at subsequent stages of the research. The core feature of grounded theory, as outlined by Foley et al. (2021: 1), is theoretical sampling, which involves "sampling participants with a set of theoretical considerations in mind." It also takes place within the data generation process through interviewing. Theoretical sampling, therefore, entails a gradual progression towards sampling participants based on emerging themes within data and concepts that are produced during the iterative analysis. This abductive approach seeks to transcend the traditional deductive-inductive divide in qualitative analysis by fostering an iterative move between data collection and theory formation.

Using this methodology, the initial interviews were conducted based on the pre-established sets of questions. Simultaneously, data analysis was underway, resulting in the creation of a codebook after the first round of interviews. This codebook included categories related to disciplinary affiliations surpassing a shared e-science identity, the preservation of disciplinary boundaries across sciences, the perceived generic

character of computational tools compared to the domain-specificity of their applications, the impact of increasing precarity in grant-based higher education on the retention of female junior faculty, the high recognition of gender disparities across sciences and in e-science, the tendency to disregard existing gender asymmetries, the discrepancy between the professed belief in e-science's potential to promote gender equality and the persistence of gender inequalities. These coded data were subsequently revisited in the light of relevant theoretical frameworks from feminist organization studies, gender mainstreaming policy implementation analysis, feminist institutionalism and STS literature. This process led to the emergence of new themes, including disciplinary boundedness, tool versus application approach, projectification, disavowal, and precarity. Questions related to these newly identified themes were incorporated into the remaining interviews to further test these themes against the data.

Findings

The 'Not So New' Conundrum: Anticipations Versus Realities

Researchers associated with eSec believed that e-science might offer an alternative career pathway in IT heavy scientific research, potentially attracting more women. However, the findings revealed a significant under-representation of women within the networked organization. Comprehensive statistics on eSec's personnel were lacking, and the membership structure was ambiguously defined. Therefore, the information provided below only gives a rough estimate of women's participation in network activities across three universities.

In 2022, the scientific computing division at the IT Department of University A comprised 65 researchers (13 professors—5 women and 8 men; 24 teachers and researchers—4 women and 20 men; 28 PhD students—9 women and 19 men). The same year, University B had 157 researchers (37 women and 129 men) affiliated with the network according to the official website of the university. In 2020, University C reported 59 researchers (8 women and 51 men) affiliated with the network, according to its annual report to the eSec. These figures indicate a stark under-representation of women. Furthermore, both vertical and horizontal gender segregation prevailed.

Nonetheless, the researchers mostly believed that e-science had the potential to attract more women to IT-heavy scientific research, citing its novelty and cross-disciplinary nature as key factors. "In some sense, I think that the focus areas have shifted [with the advent of e-science] towards data-driven sciences. And maybe there are more women there because that's new, a newer science […] There are more opportunities. And the hierarchies haven't formed themselves yet. So, that's why I think there could be more women […] I think there is a tendency for the old areas to be more male dominated," explained Ingrid[4] (female, senior researcher)

[4] The names of the interviewees are pseudonymized to maintain their confidentiality.

regarding the potential of a relatively new research field to attract more women. Nicole (female, senior researcher) concurred, saying, "I mean it's a pretty new area, I would say. And then because it is so new, I guess we have the chance to set our own stereotypes."

Researchers, such as Luca below, also emphasized the potential of cross-disciplinary convergence to reduce gender asymmetries across sciences:

> And again, it's most likely, if you just bring together topics, then I mean, it makes it much easier. I mean, if you start to do biology, you do biology, and it's mostly women, and that computer science does computer science, and it's mostly men. I mean, there are two compartments separated. And men keep working with men, women keep working with women. And it leans towards being like that. […] But the fact that those two fields meet at some point is a good way [to promote gender equality]. I mean, it is a chance for woman to go to computer science and men to go to biology (male, junior researcher).

Bengt, indeed, attested to the positive influence of this disciplinary convergence on gender equality in e-science:

> One thing that particularly comes to mind is exactly, life sciences. Medicine increasingly uses computational techniques. I believe it's slightly more women than men who study medicine. Medicine definitely doesn't have a gender problem with regards to women. The same in biology. Traditionally, fields that use computational science were engineering, physics, these types of things, then increasingly chemistry, and only let's say, in the last 20 years has it seriously started in biology and medicine. And therefore, at least in e-science in Sweden, I see an increase of women because of that (male, senior researcher).

Nonetheless, these statements only highlight the discrepancy between the anticipated potential of e-science to promote gender equality in sciences and the persistent under-representation of women in eSec. The gap between the anticipated positive gendered implications of e-science's novelty, both as a relatively new research area and as a hub for cross-fertilization across sciences, remains "non-performative" (Ahmed 2012). Why has this potential not been realized, and why do the existing gender asymmetries persist, rather than diminish, within this new networked e-science organization? The response to this question will involve an exploration of the obstacles to the realization of this professed novelty and point towards the ways in which eSec remains deeply entrenched in larger structural and disciplinary gender effects.

Organizational Obstacle: Disciplinary and Structural Embeddedness

As stated above, eSec network remains highly embedded in the general institutional setting of the higher education which obscures the practical enactment of afore-mentioned newness. I analyze this embeddedness under three categories: disciplinary boundedness, tools versus applications and project-centeredness.

Disciplinary Boundedness

eSec acts as a loose, and largely ad hoc interinstitutional networked organization centered around few principal investigators (PIs) from the disciplines of physics, chemistry, biology, and scientific computing. Being the locus of funding distribution in their respective scientific fields, or "epistemic cultures" (Knorr-Cetina 1999), these PIs act as highly individualized epistemic subjects. The concept of epistemic culture is based on the "disunity of sciences" (Galison and Stump 1996) and concerns "amalgams of arrangements and mechanisms -bonded through affinity, necessity, and historical coincidence- which, in a given field, make up *how we know what we know* (Knorr-Cetina 1999: 1). Fields, as such, constitute distinct "lifeworlds comprising, besides a scientist, materials, instruments, bench space, and help from technicians or students who may perform part of the work" (1999: 217). Scientists, as epistemic subjects, are "derivatives" of "machineries deployed in knowledge production" (1999: 11) and they remain embedded in the bounded spaces of disparate epistemic cultures. Although "distributed locations" enabled by e-infrastructure might fall outside the realm of such bounded spaces marked by specific epistemic cultures (Knorr-Cetina 2007: 367; Kasperowski and Hillman 2018), it is observed in eSec that scientists nonetheless remained embedded in their disciplinary and faculty-level attachments, as also observed elsewhere in digital transformation research (DTR) (Schmitt et al. 2023). The membership structure operative in eSec also attested to that. Researchers were deemed members of eSec network through their affiliation with certain divisions or departments, with research groups of original eSec PIs, and with projects funded by eSec at University B. When asked about the potential of e-science to contribute to gender equality, Olga (female, senior researcher) made issue of this point as follows:

> E-science is not really a self-standing research area. If it was it might have been different, but it's not. So, it's still linked and anchored in other research areas. So whatever effects we see in physics, of course, propagate in e-science, if it's e-science for the sake of physics. So, it's no different in this sense. It's not really decoupled from fields.

According to Olga, this was the reason why gender dynamics in sciences were perpetuated also in e-science collaborations. Markus (male, senior researcher) further reported that it was indeed a challenge to make scientists affiliated with the network recognize themselves as doing e-science.

> And that was our first challenge, in a way to make people recognize themselves as doing e-science. As I said, I mean, computational chemistry has been going on for many years, so that people identify, firstly, as chemists, or computational chemists, or theoretical chemists or whatever. But e-science is something new, so people don't recognize, it's kind of a word somebody else is using, I think, it is basically everywhere, because it is an umbrella term. And people don't go around thinking themselves as part of an umbrella term, they like to be more specific.

Mikael (male, senior researcher) further confirmed that most of the researchers in eSec "have a disciplinary focus in the field," and added, "I am not sure if we can talk about an e-science culture." Lara (female, senior researcher) also concurred that "the culture is more tied to domains than what you actually do." Daniel (male, senior researcher) similarly took issue with the preservation of what he called "disciplinary silos":

> The impression is that the level of ambition is not about bringing the disciplines into e-science, but rather facilitating the use of e-science across disciplines, but still within their disciplinary silos. So, eSec isn't really providing a platform for dissolving the boundaries between those disciplinary silos, but rather, it's about increasing the accessibility of e-science within each discipline.

In consequence, in eSec, interdisciplinarity was "less about overcoming disciplinary boundaries and integrating perspectives, knowledge and methods of other disciplines but about different disciplinary perspectives work side by side" (Schmitt et al. 2023). As illustrated in the citation above, this domain boundedness was indeed compounded with a particular enactment of e-science in eSec which relied on a 'tools versus applications' approach. E-science was mostly conceptualized as supporting sciences in their computationalization trajectory by providing scientists with cutting-edge computational tools, methods and applications. Mikael, for instance, finished his words on the lack of a common e-science culture by saying, "But I can pinpoint one [common culture] at least. We often think of us as having the goal to apply large scale and advanced computing to advanced or application science or industry."

Tools Versus Applications

Scientists affiliated to eSec lacked a common conceptualization of e-science, and they mostly had difficulties in defining it. "I guess I don't have a sense of what it really is," said Helena (female, junior researcher), while Lara (female, senior researcher) put forward that "nobody understands it, that's the problem." At the backdrop of this conceptual ambivalence, researchers mostly made sense of e-science through the lens of their disciplinary affiliations. Below, Olga illustrated this point, by primarily referring to the use cases of e-science in different disciplines:

> [the shift] from observational to theoretical to computational science was kind of fine. But, when we started getting a lot of data, really a lot from the new telescopes, for example, Hubble telescope produced a lot of data. Our accelerators produced a lot of data. In DNA sequencing, from every human genome, you get a lot of data, right? And then, you need computers to work with data, as well. And then you can, kind of, combine this processing of data with your modelling. So, e-science basically puts all the things together: it was theory, observation, modelling all in one package, and it was done with the help of computers. So that's at least my definition of e-science, it's difficult to explain in one word. And that's why there is no simple explanation.

For researchers situated at the scientific computing departments, on the other hand, e-science mostly signified "using advanced mathematical tools that are translated in the computer language of some sorts" (Markus) to solve scientific problems, application of "computer software algorithms to domain knowledge and data in order to generate new knowledge" (Lucia, female, senior researcher), "to do an efficient application of computing resources to study scientific issues with some amount of methodological rigor" (Ulf, male, senior researcher).

Parallelly, the ambition in e-science was to develop generic computational tools or methods to be applied in various domain sciences, in a way to "support emerging science" (Lara), or "help accelerate science" (Mikael). This approach, which is elsewhere defined as "the logic of domains" (Ribes et al. 2019), acts as an organizing principle centering computational technology development as a meta, general, or universal field of research to be applied to domain-specific areas of research. It had indeed been the aspiration of eSec for the computational technology development to be an area of research that "transcended," according to the wording on eSec's official website, domain-specific research in various scientific disciplines. Situated as a universal or domain-independent general field of research, computational technology development, sometimes deemed the proper e-science part of projects (Daniel) was to be applied to domains. This organizing principle was based on and further reinforced disciplinary boundedness of researchers, while at the same time perpetuating the existing horizontal gender segregation across sciences. This gender segregation reproduced at all levels, and in all projects. It meant that the workforce doing computational technology development remained highly male-dominated, while women located in disciplines where they were better represented, such as biological sciences and medicine, continued to be higher in number in the so-called application areas in the life sciences, environmental sciences, and medicine.

Project-Centered Organization

eSec organization predominantly revolved around funding contingent labor force to work for e-science projects at the intersection of computational tool development and domain-specific application areas. For that, eSec was defined as a "vague, umbrella organization" (Stefan, male, junior researcher), mostly acting as a funding distribution hub. In two of the universities, funding directly went to the original PIs who took part in the SRA application back in 2010, while University B started to announce open calls to attract projects from other PIs.

"What does eSec do? I mean, it gives money to very short-term projects, essentially," said Bengt, while Ulf added that eSec didn't "create a very strong sense of community. And for that reason, I do think that eSec is mainly focused on the kind of funding opportunities that have been tailored rather than on other aspects." While having a funding channel was welcome in an environment where interdisciplinary e-science projects were believed to face challenges in receiving funding from traditional agencies (Kristin, female, senior researcher), relying on short-term funding was deemed "not really a sustainable strategy" (Olga) to maintain an e-science community in the long run.

This both compounded the challenge to create an e-science epistemic culture over above established bounded spaces of existing fields and acted as a means to neatly embed eSec in the shift towards new managerialism in higher education, whose negative repercussions for gender equality have been comprehensively analyzed (Ylijoki 2015; Gill 2017; Acker and Wagner 2019; Kuldova 2021; Mason and Megoran 2021; McKeown 2022). It is indeed true that the obstacles to retain early-career researchers, both women and men, in e-science were articulated in the form of larger implications of this shift towards entrepreneurial university, manifest in the form of growing precarity due to the grant-based remuneration schemes, growing contingent positions, and lack of work-life balance.

Structural Level Obstacles: New Managerialism in Higher Education

The interviewed researchers, both junior and senior, reported adverse impacts of the neoliberalization of higher education characterized by higher reliance on external research funding (Acker and Wagner 2019), "projectification" of scientific research (Ylijoki 2015), quantification of academic performance assessment (Kuldova 2021; McKeown 2022), and the proliferation of temporary positions (Gill 2017; Mason and Megoran 2021). They stated that it had become quite unfavorable to work in academe due to the growing precarity and contingent positions, unrealistic workloads, the grant-based promotion system which impacted on especially junior female stuff. Working on e-infrastructure also implied extended workhours due to constant connectivity. This was recorded to be the number one obstacle to the retention of female contingent labor in higher academic positions. Many researchers, including Sara (female, senior researcher) below, complained about the deteriorating work-life balance in e-science.

> If you're in science, you don't stop thinking about your problem when you go home. And if you're connected, of course, you sit at night and run codes. Of course, there is stress.

Lisbeth (female, senior researcher) stated that this extended workload, coupled with the constant requirement for grant applications, deterred women from climbing the career ladder.

> And the competition, I think, is necessary in this kind of science [e-science]. So, I think people, including women, probably take it as part of the game. It can deter people with care responsibilities, because writing a grant is a significant time. It's useful for many reasons. But if you have to juggle family life, writing a grant, teaching, doing supervision, it just doesn't fit. So, it's again, a selection criterion for people who have more time to dedicate to this, because it's one extra thing.

Researchers, like Chiara (female, junior researcher) below, observed that data-savvy junior researchers of all disciplines involved in e-science tended to opt out of academe to work in industry due to the growing precarity and increasing workload there.

> In the younger generation, there is a bigger gap than before, I am not sure why. Yes, I don't know why, because it's strange, but maybe, since it's a very difficult path maybe. I don't know, probably women prefer to go to work in industry, it is a little bit safer, let's say. [….] And the path is easier. It is very easy to find a job in industry, while the path to become a researcher is very long. And you get a very long period in which you have one-year contracts. And you have no guarantee that you're going to achieve the final goal of getting into the faculty in the end. […] If you want to build a family, it's very difficult to have children while you're in this not so stable situation. And because you might get cut off after maternity leave or it's difficult to realign with your male competitors. Probably this is one of the motivations why females go towards industry.

This by now well-established structural obstacle, namely, the adverse impacts of the neoliberalization of the academy on faculty, is perpetuated and exacerbated in eSec, which is assembled in the grant-based managerialism of the higher education as a project-based networked organization mostly centered around certain PIs.

Individual Level Obstacle: The Mechanism of Disavowal

Against the backdrop of the above-discussed facets of the neoliberal entrepreneurial academy, and the role of eSec as a project-based networked organization therein, the findings of the research indicated that the psychoanalytical formula of disavowal (*Verleugnung*), "I know quite well, but all the same" (Mannoni 2003), as the distinct form of subjectivation in the neoliberal higher education governed by numbers (Kuldova 2021), permeated the affective environment of eSec on an individual level: the researchers knew very well about both the different forms of gender segregation their work entailed and the importance of overcoming gender inequalities, yet they acted as if they didn't know it, against their better knowledge (Kuldova 2019).

High Recognition of Gender Segregation and the Under-representation of Women ("I Know Very Well…")

The interviewed researchers manifested high levels of recognition regarding both the under-representation of women in eSec and in their respective disciplines, and horizontal and vertical gender segregation. Horizontal gender segregation, gender segregation across scientific disciplines, manifested itself in eSec in the form of male dominance in the part of e-science collaborations involved in computational method/tool/application development. "When it comes to pure software development [part of e-science collaborations], I still think there is a massive gender gap, I mean, it's still very much male-dominated," Samesh (male, senior researcher) reported. Application areas in e-science collaborations which are mostly situated in life sciences and environmental sciences were, on the other hand, considered to have more women:

> So, in biology and plant ecology, I'd say globally, pretty even representation of men and women across the board. But since your interest is in e-science,

> which is for me rather a suite of technologies that are useful in providing a methodological platform. And certainly, in terms of adoption of those methods within ecology and ecosystem science, it's much more male dominated than environmental sciences generally (Bruno, male, junior researcher).

Horizontal segregation was well-recognized, as was vertical segregation with fewer women climbing the career ladder. "And it also depends on what level you're in. I mean, as you know, the professors are predominantly male, but with the PhDs, you have more women," said Hanna (female, junior researcher) in the case of cognitive science, which resonated well with the observations of researchers affiliated with eSec from other disciplines.

This widespread recognition was accompanied by a strong desire for gender equality, mostly verbalized in the form of significance attributed to having female role models. Thus, there was not explicit individual resistance in eSec against the implementation of institutional measures to promote gender equality.

Disavowal ("But All the Same…")

The widespread recognition of the gender issue was accompanied by certain mechanisms serving disavowal and normalization of the under-representation of women in the field, leading to "the organizational reproduction" (Kuldova 2021) of horizontal and vertical gender segregation. There were very few researchers who outrightly denied the under-representation of women in their own field (note that these researchers interact with eSec through the mediation of their own scientific fields), such as Sara. "And as I told you, I'm in a paradise in this division [theoretical chemistry][5]. I have no problems. We have female students, teachers, professors, it's not at all a problem." Sara also reported that most of the professors in her division were female. In reality, there were 7 male and 4 female professors, and women were under-represented both among teaching staff and PhD students. It was rather disavowal which was mostly articulated by the researchers: "I know that there is imparity, but all the same..." "But actually it's [the number of women] not like zero [….] So, I mean, it's not like there is no woman," said Thomas (male, senior researcher) right after he talked about the under-representation of women in his e-science collaboration. Lisbeth below illustrated this contradictory position of disavowal marked by both knowing about the problem and acting as if it did not exist.

> So over age, the number of women diminishes. And that's the leaky pipeline phenomenon that a lot of people are aware of, unfortunately. But at the same time, from my personal experience, [scientific computing[6]] is a fairly welcoming environment. So, there's no particular… I mean, maybe it's not as bad as other places, shall we say like that? But there's also still a lot of unconscious bias and some people are affected by it. But still, it's not one of the worst

[5] As Sara was a PI associated with eSec, her research group within the division was considered as part of eSec due to this affiliation.

[6] All researchers based in the Scientific Computing Division of University A's IT department were designated as members of eSec.

> places to work for as a woman. And again, in my experience, people have been very flexible with the care responsibilities (Lisbeth).

This disavowal ("I know very well, but all the same") was accompanied by the recognition that women, being few in number, stood out in the field, giving the impression that there were more of them than the actual numbers:

"I remember sitting once in a conference thinking, 'wow, there's a lot of women here,' and then I sort of actually counted and it was like, 25%. And my perception was like, oh, it's like, almost 50/50. But it wasn't" (Hanna).

What Hanna referred to was the incongruity between appearance or her perception and reality: even few felt like 50/50. What is striking here is that the recognition of the under-representation of women, and the expressed desire to overcome it didn't necessarily amount to any change in action. So, the female researchers affiliated to eSec who were otherwise well aware of the under-representation of women both in their field of research and in eSec mostly stated that "it doesn't faze me out anymore" (Barbara, junior researcher), "I am not even thinking of it" (Oriane, junior researcher), or "I don't pay attention" (Olga). This disavowal (they know but act as if they don't) governed the affective atmosphere of eSec. Since all disavowal is ideological (Kuldova 2019), it is not surprising that this individual level resistance played out as the "psychic effect of neoliberalism" (Layton 2014) under larger structural and organizational gender effects related to the growing new managerialism in higher education.

Discussion and Conclusion

While the potential of new organizational forms facilitated by ICTs to alleviate gender asymmetries initially generated optimism, subsequent research reveals that these structures often perpetuate, and in some cases exacerbate, preexisting gender inequalities (Benschop and Brouns 2003; Hebson and Grugulis 2004; Lindgreen and Packendorff 2006; Tildesley et al. 2022). A similar pattern was evident within eSec, making it a case worthy of analysis. eSec represents an innovative project-based networked organizational form in higher education established with the strategical goal of advancing e-science. Although the novelty and potential for disciplinary cross-fertilization in e-science generated hope among its affiliated researchers for addressing gender equality within and across sciences, gendered disparities remained unaltered.

At the *organizational level*, the perpetuation of existing gender inequalities in eSec stemmed from its entrenchment within the established epistemic cultures of academia and its alignment with the contemporary new managerial shift in higher education. Affiliated researchers largely operated within the confines of the bounded spaces of their respective disciplines, conceiving e-science primarily as the infusion of cutting-edge technologies into domain sciences. This perspective limited the expected novelty of interdisciplinary cross-fertilization in e-scientific endeavors and contributed to the persistence of gendered disparities across sciences.

Furthermore, eSec, functioning as a project-based networked organization, was deeply intertwined with the ongoing transformation of higher education toward the entrepreneurial university model. This model has been linked to adverse effects on gender equality (Lipton 2017; Zheng 2018; Doerr 2022). The ramifications of this transformation, including deteriorating work-life balance and heightened job insecurity, were particularly pronounced among contingent junior faculty in academic e-science roles. This speaks to the *structural obstacle* to gender equality in eSec. This structural hurdle underscored the challenges in retaining promising junior faculty in higher academic positions. Both male and female contingent academic staff expressed a desire to leave academe due to precarity, heavy workloads—compounded by the type of e-scientific work that involved constant connection to e-infrastructure—and the strain of grant-based funding. Female contingent academic staff, in particular, bore a disproportionate burden.

On an *individual level,* researchers, including those positioned to implement gender equality recruitment measures, exhibited various forms of disavowal. The literature on gender mainstreaming policy implementation underscores individual resistance at the level of actors' policy interpretation (Cavaghan 2017). It also discusses the conflict between supporting and opposing actors (Verge and Lombardo 2019), or "power over" (Tildesley et al. 2022) imposed by dominant or privileged actors (Verloo 2018), leading to the trivialization of gender equality policies, or a denial of the need for gender analysis. Some researchers also point to both institutional and individual resistance in the form of opposition to the goal of gender equality and a lack of—or insufficient—capacity (Mergaert and Lombardo 2014). An intriguing aspect of the eSec researchers' response is the absence of such overt individual resistance. They didn't oppose gender equality; rather, they professed belief in the enduring gender equality ideal within Swedish academia and demonstrated a sound understanding of both vertical and horizontal gender segregation. Paradoxically, they often acted as if they lacked knowledge or awareness of these gender disparities, pointing towards an affective atmosphere of disavowal, a prevalent affective state in neoliberalism (Layton 2014).

Notably, the Swedish context provides a revealing backdrop. Sweden presents a setting in which the widely recognized gender equality ideal is being threatened by the weakening welfare state rationale "with collective solutions and inclusiveness" in the transition towards neoliberal new managerialism "where individual autonomy and freedom of choice are seen as means of achieving gender equality (Lane and Jordansson 2020: 28). This context has seen the entanglement of neoliberal consumer and social citizenship metaphors in discussions on higher education (Nordensvärd and Ketola 2018), and women's entrepreneurship policy (WEP), shifting focus from egalitarian ideals to "the goal of unleashing women's entrepreneurial potential so they can contribute to economic growth" (Berglund et al. 2018: 531). Consequently, there is a risk that the negative implications of neoliberal governmental rationalities may render this gender equality ideal, as also observed among eSec researchers, "non-performative" (Ahmed 2012).

While there has been limited research on the establishment of new institutional structures in response to the commercialization of academic research (Siegel and Wright 2015) and how scientists navigate these changes through sense-making

narratives (Mäkinen and Sapir 2023), a notable gap exists in our understanding on the persistence of gender inequality in emerging academic and public-industry collaborations organized within the framework of e-science. This study addresses this gap by facilitating an interdisciplinary discourse that draws from Science and Technology Studies (STS), feminist institutionalism, and organization studies. It explores the multifaceted obstacles to achieving gender equality in data-intensive research domains, particularly within the evolving organizational paradigms shaped by e-science as part of the broader transition toward the entrepreneurial academy.

As a single case study rooted in its unique national and institutional context, this research underscores the imperative for additional, preferably comparative, investigations into analogous organizational structures that have arisen within higher education in response to the advent of e-science and data-driven sciences. Such studies can enrich our understanding of the complex interplay between gender dynamics and evolving academic landscapes, contributing to a more extensive and nuanced approach towards gender equality challenges within these contexts.

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