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ABSTRACT

The Gender Pay Gap at the Early Stages of Academic Careers

The number of countries that have devoted time and attention to establishing gender equality regulations in academia is increasing. However, various studies indicate that women remain underrepresented among tenured faculty and in senior positions, and that female academic staff earn less than male ones. The reasons for these gaps, in particular those specific to academia, remain unclear. This article analyzes Polish female and male PhD graduates to measure the pay gap between them and its progression over time. The article studies the sources of the pay gap, with a special focus on parenthood. It draws on a dataset that covers the entire population of PhD holders who were awarded their degrees and were hired at any Polish university between 2014 and 2018. The study's results reveal that despite equal pay regulations, a relatively narrow (3–5%) but stable adjusted gender pay gap already exists among early-career academics who do not have children, and that the gap widens considerably when income from outside academia (6–11%) is considered. Basic incomes of mothers in academia are 18–20% lower than those of nonmothers. A substantial fatherhood wage premium (33–37%) arises when all sources of income are considered. Academia is not necessarily an equal workplace.

JEL Classification: J13, J16
Keywords: gender pay gap, women in academia, earnings, careers

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1. Introduction

Research on the gender pay gap in academia dates back to the 1970s. Since then, numerous studies have been conducted at individual universities.[1] All have found that women are underrepresented among tenured faculty and higher academic ranks, and that female faculty typically earn less than male faculty. Although many countries have devoted considerable time and attention to establishing gender equality policies and ensuring the equal treatment of men and women in the academic labor market (Salinas and Bagni 2017), pay differences between male and female faculty members persist (European Commission 2021). Due to the significant gender pay gap, work–family conflicts, and female academics not yet seeing themselves as deeply embedded in the scientific community, women in the early stages of their careers are particularly vulnerable to leaving academia or science entirely (Wolfinger et al. 2009). Although the gender pay gap remains a critical challenge in academia, its nature and its determinants are not fully understood. Although many of the factors behind gender pay differences are shared between academia and other sectors or occupations, several are specific to academia and are little recognized. For instance, while the measurement of scientists' productivity is possible, it is challenging in practice. Prestige and recognition form the basic currency of the science sector, and they are achieved first and foremost through publications in top journals and via top publishing houses (Fochler et al. 2016; Lindahl 2018). Scholars are required to be scientifically productive, and in Anglo-Saxon systems, prestige and funds derive primarily from research activities. In Europe, by contrast, high salaries are more likely to be obtained in high-level administrative roles (Kwiek 2018). Teaching activities are often considered to be of lower value than research, and it is difficult to measure teaching productivity (Boring 2017). Finally, workers in the academic sector tend to have different sources of income, which, in turn, are subject to different gender gaps. This issue is particularly important in the Central and Eastern European (CEE) context that this article explores.

At the early stages of their careers, the remuneration of women and men tends to be more equitable than it is at the later stages. The process of hiring and determining the appropriate salary typically involves a rigorous assessment of an individual's qualifications; however, the influence of nonlegitimate criteria on an individual's annual salary is likely to increase with the number of years since they were initially hired or promoted (Sato et al. 2021). Thus, the tendency for women to be offered lower initial salaries followed by more modest rises

[1] For instance, for the US: Carlin et al., 2013; Chen and Crown, 2019; Australia: Currie and Hill, 2013; Canada: Brown and Troutt, 2017; Sweden: Gonäs and Bergman, 2009.

causes the gender pay gap to increase year by year, and is likely to put women at a career-long disadvantage (Amilon and Persson 2013; Claypool et al. 2017; Momani et al. 2019; Perna 2001; Takahashi and Takahashi 2011).

Most of the current evidence on gender pay differences in the academic sector comes from Western European and Anglo-Saxon countries, with their distinct institutional and educational settings, and employment and pay policies. This article focuses on Poland, a CEE country that has undergone far reaching economic and educational changes since 1989. Despite growing public interest in gender equality in the CEE region, there remains a dearth of research on the gender dimension of the academic sector, and in particular on salary differences in academia. Like other CEE countries, Poland has reformed its science and higher education sectors to ensure a more competitive allocation of research funds, thereby increasing the impact of the economy on science and rewarding international collaboration (Bieliński and Tomczyńska 2019). The marketization of the science sector in Poland has brought it closer to the Anglo-Saxon model, which is founded on productivity, efficiency, and effectiveness in knowledge production. This direction of change in Poland might lead to a wider gender pay gap, as men tend to invest more time in research than women, and are more likely than women to be promoted to higher positions, hold full professorships, and to have lighter teaching and administrative loads (Abramo et al. 2009; Blackaby et al. 2005; Gibney 2017; Ginther and Hayes 2003; Guarino and Borden 2017; Hesli and Lee 2011; Mitchell and Hesli 2013; O'Meara et al. 2017; Perna 2003; Takahashi et al. 2018).

This article aims to shed light on the determinants of scholars' incomes in the early stages of their academic careers in Poland, and the width of the potential gender gaps in their pay. In particular, it addresses the following research questions: (1) Is there a pay gap among recent male and female PhD graduates who work in academia?; (2) Can this gap be explained by differences in male and female researchers' individual and workplace characteristics?; (3) How is the gender pay gap in academia evolving?; (4) Do differences in the amount of extra-university income men and women earn contribute to the gender pay gap?; and (5) In particular, does parenthood contribute to the gender pay gap among scholars?

An essential advantage of this research is that it can draw on a unique administrative dataset that covers the entire population of PhD holders who were awarded their degrees and were hired at any Polish university between 2014 and 2018. The data comes from the Polish Graduate Tracking System (ELA). The dataset contains individual data on the salaries and research productivity of PhD holders that are extracted from universities, and are merged with income and employment history data from the Social Insurance Institution registers.

The research makes three main contributions to the literature on the gender pay gap in academia. First it focuses on the early stages of academic careers, which are crucial for the later career development of male and female faculty researchers alike. Second it provides evidence on the gender pay gap in a setting that differs from those that have been previously studied: specifically, in a CEE country with a heavily reformed academic sector, a large share of women in lower-level academic positions, and a large share of scientists with multiple income sources. Third, in light of the differences in the institutional settings of academia between Poland and the Western European countries, it revisits the factors that are known to contribute to the gender pay gap in academia, while also examining new factors that have rarely been studied, such as whether an institution is public or private, the degree of feminization in the field of study, and the role of additional sources of income among faculty members.

We find that men who graduated with PhD diplomas and work in academia earn considerably more than women in the same circumstances. The average difference is 15–18% for incomes from academia and 25–26% if all sources of income are considered. This raw pay gap is only partially explained by differences in male and female researchers' individual and workplace characteristics. The pay gap is particularly high among parents and in incomes outside of academia.

This article is organized as follows. It commences by reviewing the literature on the potential determinants of gender pay differences in the academic labor market. It then describes the positions women tend to hold in academia in Poland. Next it describes the data and the methods we use, and present the results of our analyses. It later discusses our findings and their implications. The article concludes with our thoughts on directions for future research.

2. Determinants of the gender pay gap in academia

A rich literature has developed on the gender pay gap (Blau and Kahn 2017 offer a comprehensive review), which has identified gender sectoral and occupational segregation, and motherhood penalties among the most important factors in the gender pay gap. We intend to contribute to this strand of the literature by focusing on the gender pay gap in a single sector, academia—and specifically on the young employees and PhD graduates who work in it. Only a few existing studies of gender pay gaps have focused on subgroups of workers, such as young university graduates (Bobbitt-Zeher 2007; Goldin et al. 2017) or graduates in a particular field of study (Ceci et al. 2014). When studying the gender pay gap, such a narrow focus has its

advantages. First, such an endeavor is not limited by the need to control for sectoral segregation, a highly relevant factor in gender pay inequality. Second, several factors that are peculiar to the academic working environment could play roles in gender differences in pay. Our study is able to adjust for these factors.

In particular, we measure (or proxy) potential research productivity differences between men and women that could contribute to gender pay inequality. Researchers' productivity is typically measured by the number of publications or research grants they receive. Many studies have found a male advantage in productivity (Abramo et al. 2009; Blackaby et al. 2005; Ceci et al. 2014; Hesli and Lee 2011), and that the differences in the numbers of publications and grants men and women receive explain a substantial portion of the gender pay gap (Perna 2003; Takahashi et al. 2018). Other studies have found that female academics spend less time than male ones on research due to their higher teaching and/or service loads (Gibney 2017; Guarino and Borden 2017; Mitchell and Hesli 2013; O'Meara et al. 2017; Takahashi et al. 2018). Samaniego et al. (2023) demonstrated that cumulative research productivity related more strongly to compensation for male than for female researchers—although this effect was revealed exclusively in STEM disciplines. The question arises whether the correlation between productivity and compensation also exists at the beginnings of scientific careers when the researchers have authored fewer works.

Mixed evidence exists on whether women are as likely as men to have their manuscripts reviewed and their grant proposals funded (Lundberg and Stearns 2019; Krawczyk and Smyk 2016; Witteman et al. 2019), which might impact their research productivity via a discrimination channel. While the experiment by Krawczyk and Smyk (2016) revealed that female authors were perceived as less competent than male ones and were less often believed that their papers had been published, Card et al. (2020) found no evidence of differential gender bias among reviewers or editors when studying their decisions at four leading economics journals. Ceci et al. (2014) likewise concluded that manuscript reviewing and grant funding are gender-neutral. In contrast, Sarsons (2017) found that women benefitted less markedly than men from their contributions to coauthored publications, particularly when men were named as coauthors in the same publications. Moss-Racusin et al. (2012), in turn, provided evidence of a gender bias in academia, demonstrating that compared to (identical) female applicants, male applicants are perceived to be more competent and suitable for positions, and are offered higher salaries and more career mentoring. This kind of bias reflects widespread cultural stereotypes that emphasize men's scientific competence. In consequence, the ex-ante perception of greater male productivity is likely to result in salary differences that might not be justified by ex-post

productivity. Harris et al. (2023), using the latest data provided by British universities and controlling for a range of covariates, confirm that women earn less than men, and suggest that bias rather than differences in their research productivity is the cause. The doubts regarding the relationship between productivity and the gender pay gap justify the need for further research on this subject.

We contribute to this strand of literature by utilizing the fact that a publication points system is applied in the parametric evaluation of academic institutions in Poland, which is conducted every four years. While the grading of monographs and academic journals[2] was originally designed to serve as one of several assessment criteria in the evaluation of academic institutions, it has in recent years become an informal point of reference for valuing scientific work and the quality of individual scientists' research. For an institution, the points awarded for the publications of its researchers contribute substantially to the results of its evaluation, and thus to the subsidies it receives from the central government budget. Scientists who are capable of earning more points for their institutions might be perceived to be more productive, and thus deserving of higher remuneration. We therefore operationalize scientific productivity as the annual mean number of points awarded for publications scaled in a field of science.

Differences in the characteristics of academic institutions are also likely to contribute to the gender pay gap (Monroe and Chiu 2010; Nettles et al. 2000). Most of the previous studies on this subject focus on the features of the institutions that hire researchers; no consensus has been established, however, on whether the characteristics of the academic institutions from which PhD holders graduated contribute to the gender pay gap. For instance, the evidence on whether the width of the gender pay gap differs between public and private universities is inconclusive. Research conducted in Japan revealed identical wage differences between women and men at both types of university (Takahashi et al. 2018) and a considerable gender pay gap at public universities, despite the existence of rigid pay scales based on the experience, ages, and educational attainment of academics (Takahashi and Takahashi, 2011). Simultaneously, according to Rabovsky and Lee (2018), greater reliance on public funding results in narrower wage differences between men and women, while dependence on competitive research funding is linked to wider pay gaps. Moreover, Monroe and Chiu (2010) discovered that while top research institutions pay scholars more than other universities (Nettles et al. 2000; Smart 1991; Toutkoushian 1998), gender pay inequalities widen with an institution's prestige. In Poland,

[2] Each scientific journal is assigned a number of points by the Polish Ministry of Science. The higher the quality of the journal, the higher the number of points. Each researcher is encouraged to publish in journals of higher quality, and these points serve as a proxy for productivity.

the institutions that are considered the most prestigious are the ones that are authorised to confer the academic degree of *doctor habilitatus* (the majority of them are public) and those that obtain the highest grades in the nationwide evaluation of the scientific activity. It is worth examining whether the prestige of academic institutions and their ownership (public vs. private) impact the remuneration offered to the early stage scientists to whom they confer research degrees and, consequently, the gender pay gap.

This study adjusts the gender pay gap that we estimate for a set of characteristics of the academic institutions from which young people graduate (such as whether an institution is public or private, the scientific quality of an institution, and the academic field in which a PhD was obtained). These characteristics might determine the reputation of a university, while also serving as an indicator of a graduate's educational attainment. Claypool et al. (2017) found that graduating from a highly ranked PhD program has a positive effect on salary. We examine whether the patterns of the interactions of gender and the characteristics of the academic institutions that employ graduates reported in research on the gender pay gap are the same as those of the institutions from which the PhD holders graduated.

The feminization or the masculinization of academic fields might also influence the width of the gender pay gap in these fields, or among their graduates. Academics who work in fields that employ significantly more women than men typically earn less than their peers in male-dominated fields (Perna 2001; Perna 2003; Smart 1991; Umbach 2007). Both men and women tend to pursue different disciplines, and women are particularly underrepresented in STEM fields, which offer higher salaries (Brown and Corcoran 1997; Zhang 2008). Evidence on the gender pay gap in STEM remains limited (Gerber and Cheung 2008; Silander et al. 2013; Xu 2015; Zając et al. 2024, Zhang 2008). In one of the few studies that addresses this issue, Momani et al. (2019) discovered that the gender pay gap is wider in the STEM disciplines than in non-STEM ones, but also that the average salary differences between female and male faculty are narrower in disciplines in which more women participate. There is also evidence that gender bias persists even in fields in which the representation of women has increased considerably (Begeny et al. 2020). The heterogeneity of pay differences between men and women who work in and graduate from different academic fields, and the role of feminization in the gender pay gap in academia, also merit further research. This article also aims to address those areas.

Our research examines the role of parenthood, which has been reported widely in the recent literature as a crucial driver of the pay gap. Men who become fathers are rewarded with higher incomes (Correll et al. 2007; Hodges and Budig 2010; Killewald 2013), and this is particularly true for high earners (Glauber 2018). Women who become mothers experience a

so-called "motherhood penalty", a wage gap associated with motherhood. Cukrowska-Torzewska and Matysiak (2020), in a meta-analysis that relies on ninety-five empirical studies on the motherhood wage penalty, found an average wage gap associated with being a mother of approximately 3.6–3.8%. The gap is explained primarily by the loss of human capital during child-related career breaks.

Academia is a domain in which the interruptions that result from having children can substantially hamper career advancement. Some studies confirm the negative impact of being a mother on publication productivity (Lutter and Schröder 2020; Mairesse et al. 2019; Morgan et al. 2021), promotion process (Finkel and Olswang 1996; Mason et al. 2013), scientific collaboration (Hunter and Leahey 2010), and academic mobility (Wagner et al. 2017). For this reason, the so-called "stop-the-clock" policies, as discussed by Manchester et al. (2010), are being implemented more frequently. They aim to extend, due to major life events, the time allotted for academic assessment, degree attainment, or grant settlement. Nevertheless, the mere fact of having children harms mothers' salaries in academia. An incremental decline in women's incomes with each child (Mason et al. 2013, p. 88) and clear evidence of fatherhood premiums have been identified (Kelly and Grant 2012).

The differences between male and female incomes in academia may be narrowed by collective bargaining, but are likely to be wider under decentralized, individualized wage-setting schemes (Claypool et al. 2017; Gonäs and Bergman 2009). Women might be less aggressive in asking for promotions and pay raises. Moreover, they receive fewer job offers than men with comparable characteristics and are more risk-averse due to family responsibilities (Blackaby et al. 2005). Women's lower job mobility gives university employers monopsonistic power and enables them to pay women less than men (Takahashi and Takahashi 2011).

This article differentiates between the types of income academics earn from their main employers and from external sources. Most studies on the gender pay gap in academia focus on the base salary scholars receive from the academic institutions at which they are employed. However, the earning of supplemental income—either for additional services rendered within academia or for consulting and other services undertaken outside academia—is a widely accepted practice in academia, and Poland is no different. Perna (2002) discovered that compared to their male counterparts, female academics are less likely to earn supplemental incomes, and that the supplemental income they do earn is, on average, lower. However, the evidence on how these forms of additional income influence gender pay differentials in academia is severely limited. We intend to shed more light on this issue.

Finally, this article offers additional evidence on the gender pay gap in academia in Poland, a CEE country. This context has rarely been studied and is ripe for further exploration.

3. Women in academia in Poland and the European Union

The institutional setting of academia in Poland differs from those of Western European and Anglo-Saxon countries along several dimensions. In Poland, women constitute a relatively large share of PhD graduates (56%, compared to an average of 47% in the EU-15—so-called "old Europe"—which puts Poland in fourth place among the EU-27 countries). This female advantage also holds among academic staff: in Poland, women constitute 51% of academic staff with a PhD, compared to 46% in Western European countries. However, Poland also has high rates of attrition at subsequent academic career stages (a "leaky pipeline"). Thus, the female advantage among early-career researchers is promptly lost, with women constituting only 39% of associate professors and 25% of full professors. By comparison, the respective shares in the EU-15 countries, are, on average, 42% and 22%.

Other former socialist CEE countries also have relatively high shares of female researchers. This pattern reflects both the historically high female labor force participation rates and the Soviet legacy of gender equality as part of the official socialist agenda. Moreover, for many years, academia has been a low-paid sector; thus, the so-called "field status paradox" plays an important role: "When the status of a field is low, women will be found in large numbers" (Etzkowitz and Ranga 2011).

Distinct patterns of gendered attrition can be observed in different fields of study. In the EU-15, the shares of women among graduates at the master's level vary between 74% in education and a mere 24% in information and communication technologies (ICT). In Poland, the respective proportions are 86% for education and 20% for ICT; however, among doctoral graduates in STEM, the share of women is 37.5% in the EU-15, compared to 49% in Poland. Poland has the highest share of female PhD STEM graduates in the EU.

Little is known about wage progression in academia in CEE countries, particularly from a gender perspective. While the "raw" (unadjusted) gender pay gap in Poland is relatively narrow (5–8%), it is much wider when adjusted for personal and workplace characteristics

(over 15%, with the CEE countries having wider adjusted gender pay differences than the Western European countries).[3]

Other features of the Polish academic institutional setting that might be relevant to our study concern the sector's partial privatization during the transition to a market economy in the 1990s and the implementation of efficiency-seeking reforms (Kwiek 2014): "Fostering this growth were equally liberal approaches to quality assurance mechanisms, licensing, and accreditation that encouraged the nascent private sector during its first decade of its operation" (Kwiek 2012: 134–135). The number of private higher education institutions increased considerably (from 36 in 1994 to 274 in 2004), as did the number of students who attended private institutions (from 29,000 in 1994 to 546,000 in 2004). The share of all students who attended private universities reached 30% at the beginning of the 2000s. However, the number of academic teachers who worked at private universities increased only modestly, as most academic teachers continued to work for public universities[4], while also earning additional income from the newly established tertiary education institutions. We account for this supplementary income, as it is highly relevant in understanding the gender pay gap in Polish academia.

Academic institutional settings differ across countries, including with respect to their funding and assessed quality levels (which often translate into financing). In Poland, the quality of academic institutions is assessed every four years in a nationwide evaluation of scientific activity. The evaluation process investigates institutions' scientific, research, and development activities. In 2017 each institution was assigned to one of four categories: A+ (a national leader), A (very good), B (satisfactory, with a recommendation to strengthen its scientific activity), or C (unsatisfactory). The budgetary resources allocated to institutions depend on their grades, and might influence the salaries they pay. However, the regulatory framework of pay setting is more complex. Although Polish public universities determine their employees' salaries autonomously, they are obliged to follow the ministerial rules on the minimum basic salaries for full, associate, and assistant professors. Private universities are less reliant on state funding and do not have to conform to state-mandated salary scales. Thus, questions arise whether scientific institutions with higher salaries have wider adjusted gender pay gaps, and whether these gaps differ between public and private entities. While we are unable to study these issues

[3] Eurostat (online data code: sdg_05_20), accessed on March 3, 2022.
[4] In 2012, approximately 9% of all academic teachers worked at more than one university (data from POL-on, the Polish Science and Higher Education register). Among academic teachers employed at private universities, the share was 38%.

directly, we investigate whether gender pay gaps are narrower among graduates of public universities.

4. Data and sample description

We used data on the entire population of PhD holders who were awarded their degrees between 2014 and 2018 in Poland. We observed their labor market outcomes in the 2015–2020 period.[5] The data comes from the 6th edition of the Polish Graduate Tracking System (MNiSW 2021, hereafter ELA), which links data from two administrative registers: the Science and Higher Education register and the Social Insurance Institution register. The dataset covers a range of characteristics, including: 1) gender, age, and year when a PhD was awarded; 2) the field of science in which a degree was awarded; 3) the academic institution that awarded a degree, whether it was public or private, and its quality grade; 4) the PhD holder's detailed labor market status (described by the code of social security contributions paid) and labor market history (employment status, type of employment contract if employed, self-employed status, unemployment status, being on sickness or maternity or parental leave); 5) the amount of social security contributions paid, which enables us to calculate the labor income earned; and 6) a set of scientific individual productivity measures based on a PhD holder's publication record. We also calculate the degree of feminization of different fields of study (the share of women among a field's graduates) to adjust for the potential link between the share of female academics in a given field and the salaries paid to male and female researchers.

Since our aim is to study the gender pay gap in the academic sector, our final dataset contains data only on PhD graduates who remained employed at Polish academic institutions in each consecutive year after they obtained their PhDs during the analyzed period. We exclude self-employed workers, as we lack data on their total incomes (they pay social security contributions on a minimum basis, irrespective of total income earned). The main dataset also excludes individuals employed at C-grade institutions and church institutions, due to the low number of graduates in these categories.[6]

As discussed in the literature review, parenthood appears to be the crucial factor behind gender gaps in earnings. We explore this relationship by controlling both for parenthood and

[5] For the first two cohorts of PhD graduates, from 2014 and 2015, a full five-year monitoring period is available. For subsequent cohorts, the set of annual indicators decreases by one; thus, the 2018 cohort can be monitored for two years after they obtained their degrees.

[6] The results do not change if we enlarge the sample by adding C-level institutions or church institutions. The results are available upon request.

its interaction with gender. Although we cannot observe children directly in our database, we capture parenthood by observing whether individuals have used maternity, paternity, or parental leave.[7] The final dataset contains data on 24,573 individuals (see Table 1) and 50,987 person-year observations (see Table A in the Appendix).

4.1 Descriptive statistics

Table 1 presents the key descriptive statistics. The number of students who graduate each year (and commence paid work in academia) is roughly equal over time, at approximately 4,697 to 5,143 individuals. We observe a stable share of women among PhD graduates in consecutive years of approximately 54–54.6%. We also calculated the share of individuals who moved to nonacademic sectors at least one year after being awarded their degrees to discover whether any gender patterns could bias our analysis. We discovered that approximately 39% to 45% of PhD graduates took up and maintained employment at academic institutions in the five years after they were awarded their degrees. In each cohort, over 90% of PhD holders remained at academic institutions after the first year of employment, with no specific patterns by gender (cf. Table 1). Moreover, most (61.5–68.5%) of the PhD holders were employed at the academic institution from which they graduated eight years after being awarded their PhDs.[8]

Table 1. Sample size and structure, by year of graduation

year of PhD	number of distinct individuals in analyzed subset	% of females in analyzed subset	% of drop out from academia in 2nd year after PhD	
			men, analyzed subset	women, analyzed subset
2014	4,799	54.14%	2.80%	2.98%
2015	5,143	54.14%	2.65%	3.08%
2016	5,011	54.50%	3.18%	2.91%
2017	4,697	54.09%	3.88%	4.34%
2018	4,923	54.61%	5.47%	6.32%
sum	24,573	—	—	—

[7] We might fail to attribute parenthood status to fathers and mothers who had children prior to obtaining an employment contract in academia, or any other employment contract (which is necessary to become eligible to parental and maternity leave). However, we expect that most women decided and managed to enter formal employment prior to having children (even for one month), as this offered them relatively generous periods of leave during pregnancy and maternity. We are more likely to underestimate the number of fathers, as they remain much less likely to use childcare leave. We underestimate fatherhood in our data if fathers do not use a single day of leave to which they are entitled (paternity leave lasts for two weeks and is paid 100% by social security, which offers an incentive to use it).

[8] According to the Polish Science and Higher Education register, https://polon.nauka.gov.pl/en/, accessed on June 28, 2023.

Table B in the Appendix presents the share of parents among men and women, by year of graduation. Among men and women who graduated in 2014, 16% and 36% are parents, respectively; among the most recent cohorts, 7% of men and 16% of women are parents. These statistics confirm that women are more likely to become parents earlier than men.

Table C in the Appendix summarizes the variables used in this analysis by time elapsed since graduation. Most of the observed individuals have degrees in the social sciences, the humanities, in engineering, or in medical and health sciences. The data also indicates the relative insignificance of private education at the PhD level, as only approximately 1.57–1.69% of the PhD graduates were awarded their degrees at private institutions (in part because most private institutions are not permitted to offer PhD-level studies or to award PhD degrees). Moreover, most PhD graduates were awarded their degrees from high-quality (A-grade) research institutions. The average rate of feminization in the fields of science in which the PhD students graduated is approximately 47–49%, which suggests a relatively high degree of gender equality. The proportion of women is the lowest in engineering and technology, ranging from 32% to 39%, and the highest in medical and health sciences, in which the figure reaches 54%. Finally, we compared the labor income of PhD holders in two ways: by looking at their (1) income from employment contracts in academia; and at their (2) total income (income from all types of contracts, including standard employment contracts and civil code contracts) from sources both in and beyond academia.

5. Empirical strategy

To study the gender pay gap in labor income, we used hierarchical linear models. These enabled us to adjust gender differences in income for the individual-level characteristics and features of the academic institutions at which PhD degrees were awarded. Considering the nested structure of the data, employing hierarchical regression accounts for heterogeneity of regression, which is a variation of regression parameters across clustering factors (Raudenbush and Bryk 2002). In the models, we pooled all individual-year observations.[9]

Log mean annual income from paid employment at a scientific institution (employment contracts) and log mean annual total income (all types of contracts in and beyond academia) of individuals i from institution j are the dependent variables we estimate $(logIncome_{i,j})$, and

[9] Statistical analysis, data transformation, and model estimation are conducted using *R* Language and Environment for Statistical Computing (R Core Team 2020). The models are estimated using maximum likelihood and BOBYQA optimization with the lme4 package (Bates et al. 2015).

gender is our key independent variable. We started with the model that accounts for gender, parenthood, gender*parenthood interaction, time, cohort, and time*cohort interaction (Model 1).

Model 1:

$$logIncome_{i,j} = \beta_{0,j} + \beta_{1,0} \cdot time_{2.i,j} + \cdots + \beta_{4,0} \cdot time_{5.i,j} + \beta_{5,0} \cdot cohort_{2.i,j} + \cdots + \beta_{8,0} \cdot cohort_{5.i,j} + \beta_{9,0} \cdot gender_{i,j} + \beta_{10,0} \cdot parent_{i,j} + \beta_{11\ldots20,0} \cdot time_{2\ldots5.i,j} \cdot cohort_{2\ldots5.i,j} + \beta_{21} \cdot gender_{i,j} \cdot parent_{i,j} + r_{i,j}$$

Next, we added individual-level predictors in subsequent models: age and age at which a PhD was awarded (Model 2); the field of science in which a PhD was awarded, its degree of feminization, and the parametric evaluation category of the institution at which it was awarded (Model 3). In Model 4, we adjusted for productivity measures, captured by the mean annual points earned for publications, as well as for the type of academic institution (public/private).

We then estimated the models based on Model 4, supplemented with interactions of gender and age, age at which a PhD was awarded, the year after a PhD was obtained, parametric evaluation category, academic productivity, type of academic institution, and field of science (Model 5–Model 11).

The data we have enabled us to study the role of the institutions from which young PhD holders graduated, but not that of the institutions at which they work. This transpired to be a minor limitation of our study, as approximately 61.5–68.5% of PhD graduates who remain in academia continue working at the institution from which they graduated in eight consecutive years after being awarded their PhDs.[10] This enabled us to shed light on the role of academic institutions in shaping the gender pay gap.

6. Results

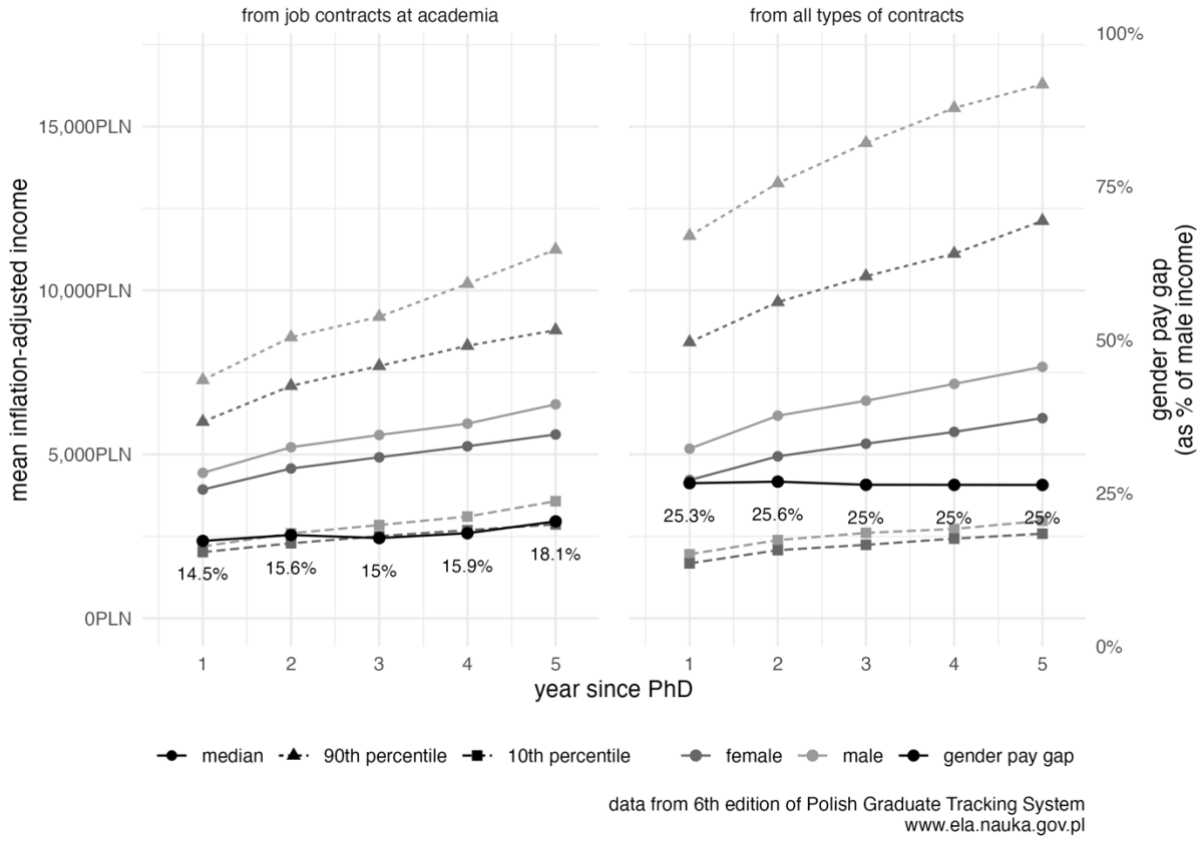
6.1 Descriptive dynamics of wages and the gender gap in basic income

We commenced our analysis of the gender gap in income in Polish academia by investigating the pay dynamics among young men and women who work in the sector. We did so by studying the income they derive from their employment contracts at their main academic workplaces. Figure 1 presents the changes over time in average male and female income from employment contracts in academia (left axis). A raw gender pay gap can already be observed

[10] According to the Polish Science and Higher Education register, https://polon.nauka.gov.pl/en/, accessed on June 28, 2023.

upon labor market entry: in the first year of employment, the average difference between men's and women's wages amounts to 14.5% of the male wage (right axis). We observe real wage growth over time (five years after a PhD is awarded, average salaries for PhD holders are over 50% higher than in the first year—see the left panel in Figure 1 and Table C in the Appendix). We also observe increasing income dispersion as earnings at the bottom and top decile diverge. Simultaneously we observe the average raw gender pay gap decreasing slightly in the third year, and increasing to 18.1% in the fifth year after a PhD is awarded.

Fig 1 Inflation-adjusted income and raw gender pay gap by year since PhD completion



6.2 Adjusted gender pay gaps in basic incomes from academia only

The raw differences in the pay of men and women who work in academia become much narrower when incomes are adjusted for a set of employees' and academic institutions' characteristics. Across model specifications in Table 1, the adjusted gender gap in academic income amounts to 3.2–4.8% for statistically significant estimates (Table 1 presents a summary of the estimates of the coefficients attached to the female dummy in the models discussed in the empirical strategy; the full set of estimates is presented in the Appendix, Table D). The gender gap in salaries shrinks (compared to the raw gender pay gap) to 4.7% when only time,

and cohort dummies, as well as their interactions, are conditioned. These results prove that PhD graduates who work in entry-level jobs in academia differ with respect to their characteristics and those of their institutions, and that some of these differences widen the raw pay gaps. When these characteristics are controlled for, the pay differences between "similar" men and women are much narrower—although they still exist. In other words, while the adjusted (unexplained) gender wage gap in academia is narrower than the raw differences in men's and women's pay would suggest, female PhD graduates still earn less than "similar" male PhD graduates—even at the entry level.

As discussed in the literature, parenthood is an important driver of the observed differences in pay, including among young PhD graduates in academia; however, a pay gap of 4–5% exists even among men and women who do not have children, all other things equal. The *parent* variable (Table 1, column 2) demonstrates the difference in incomes between fathers and nonfathers. This difference is narrow (men who have children earn approximately 3% less than those who do not) and is statistically insignificant. This effect stands in contrast to most of the current literature, which suggests the existence of a fatherhood premium. A potential explanation behind these differences is offered in the Conclusions section of this article.

The effects of parenthood on pay primarily concern women: women who are mothers earn 18–20% less than those who do not have children (Table 2, column 2 and 3). These results hold strong across all model specifications. The estimated pay gaps associated with motherhood are much wider than the average gaps found by Cukrowska-Torzewska and Matysiak (2020), which suggests that despite expectations of a more equal and family friendly work environment, parenthood remains associated with substantial wage penalties—which apply exclusively to women.

Table 2. The gender pay gap in employment contracts in academia

Column	**[1]**	**[2]**	**[3]**	
Model	**Female** **Exp(B)**	**Parent** **Exp(B)**	**Female*Parent** **Exp(B)**	**Controls**
Model1	**0.953*****	0.967	**0.829*****	time, cohort, time*cohort
Model2	**0.952*****	0.971	**0.831*****	Model1 + age, age of being awarded PhD
Model3	**0.961****	0.962	**0.838*****	Model1 + field of study, grade, degree of feminization
Model4	0.968*	0.978	**0.845*****	Model1 + publication record, HEI ownership

Model5	**0.957****	0.961	**0.860*****	Model4 + gender*age
Model6	0.961	0.961	**0.860*****	Model4 + gender*age of obtaining PhD
Model7	0.986	0.967	**0.847*****	Model4 + gender*time
Model8	0.960*	0.968	**0.845*****	Model4 + gender*evaluation
Model9	**0.964*****	0.968	**0.845*****	Model4 + gender*productivity
Model10	0.998	0.968	**0.845*****	Model4 + gender*HEI ownership
Model11	1.002	0.964	**0.850*****	Model4 + gender*field of study

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

What other factors are associated with earning higher or lower income? The results in Table D in the Appendix enabled us to investigate the determinants of pay in academia for both men and women in depth. We discovered an age premium for PhD graduates aged 33–40 compared to graduates of younger ages. Men and women who graduated in 2018 also enjoy a wage premium compared to other cohorts, irrespective of the number of years since graduation. This likely relates to the reforms of the remuneration system in 2017–2018, which offered pay rises to young researchers in particular. The field of science also matters: pay in academia is the highest among graduates with engineering and technology degrees (15–26% higher than among graduates with social science degrees) and is the lowest among graduates with humanities and arts or medical sciences degrees (10–11% lower than among those with social science degrees). A positive association also exists between productivity (as measured by publication records) and pay (around 10%). Simultaneously, the "quality" of a graduate's institution, whether it is public or private, and the feminization of the field of science in which a PhD was awarded appear to have little impact (1–2%) on a graduate's academic pay.

Only some of these associations differ between male and female researchers and contribute to gender pay gaps. For instance, while pay is the highest among PhD graduates with engineering and technology degrees, the widest adjusted gender pay gap is also observed among graduates with degrees in this field (15%, cf. Model 11). We identified no statistically significant association between women's pay and the quality of their universities or whether they were public or private. Moreover, we observed no association between researchers' productivity, as measured by the points awarded for publications, and the gender pay gap. Finally, we observed that the adjusted gender pay gaps are quite stable over the analyzed period.

6.3 Gender pay gaps in total income

We re-run our analysis but used a different measure of income, which accounts not only for basic pay from employment contracts in academia, but also for additional income earned in or beyond academia through either employment contracts or civil law contracts.

First we observed that the raw gender pay gaps are much wider if all forms of income are considered (around 25%), rather than only basic income from employment contracts in academia (Figure 1, right panel). This suggests that compared to women, men on average earn higher supplementary incomes, even though men are not more likely to earn additional income. Our data shows that the share of researchers who earn income from multiple sources is 27–38% among men and 27–34% among women, depending on the year of observation. The raw gender pay gap in total income earned is 7–10 percentage points wider than the gender pay gap in basic income from academia only.

Table 3. The gender pay gap: income from academia and from external sources

Column	**[1]**	**[2]**	**[3]**	
Model	**Female**	**Parent**	**Female* Parent**	**Controls**
	Exp(B)	**Exp(B)**	**Exp(B)**	
Model1	0.897***	1,332***	0,666***	time, cohort, time*cohort
Model2	0.899***	1,364***	0,669***	Model1 + age, age of being awarded PhD
Model3	0.909***	1,347***	0,672***	Model1 + field of study, grade, degree of feminization
Model4	0.915***	1,364***	0,673***	Model1 + publication record, HEI ownership
Model5	0.893***	1,350***	0,690***	Model4 + gender*age
Model6	0.928*	1,349***	0,690***	Model4 + gender*age of obtaining PhD
Model7	0.937***	1,364***	0,674***	Model4 + gender*time
Model8	0.885***	1,366***	0,673***	Model4 + gender*evaluation
Model9	0.914***	1,364***	0,674***	Model4 + gender*productivity
Model10	1.142	1,363***	0,674***	Model4 + gender*HEI ownership
Model11	0.924**	1,359***	0,676***	Model4 + gender*field of study

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

The gender pay gap in total income is again narrower when the raw differences in pay for individual and workplace characteristics are adjusted (Table 3, detailed results are available in the Appendix, Table E). The adjusted, unexplained pay gap amounts to 6–11% among men

and women who do not have children (column 1) when all forms of income are considered (compared to a pay gap of 4–5% for main incomes from academia only). These differences in gender pay gaps become much wider for parents. Men who have children earn in total 33–37% more than men who do not have children, which makes a substantial difference compared to the insignificant gap of 3% observed in incomes from academia only. A decrease in the pay gap from all sources of income can be observed between mothers and nonmothers: the former earn between 0.2% less and 6% more than the latter. Therefore, the motherhood wage penalties in academia appear primarily to concern basic incomes and these penalties are much smaller for total incomes. In contrast, the fatherhood wage premium emerges when total income is considered. Basic salaries are similar for men with and without children. In other words, the gender pay gaps vary widely depending on the source of income considered. These pay gaps are largely driven by parenthood but work according to different mechanisms for fathers (who enjoy a large pay premium from total income) and mothers (who earn much higher basic incomes than nonmothers in academia). Nevertheless, it appears that young graduates are far from experiencing pay equality or a family friendly working environment.

Although income from all sources increases over time, the patterns of those increases are similar for men and women, and there is no statistically significant change in the adjusted gender pay gap over time. The other patterns observed for income from employment contracts in academia also hold for income defined more broadly. Interestingly, women are more likely to be better rewarded for productivity when all sources of income are considered. The gender pay gap is also narrower among women aged 40+ than among women under age 33. Among medical and health science graduates, women on average have total incomes that are 18% higher than that of men. In that field, women outnumber men: in 2021 in Poland, female academic teachers in medicine accounted for 57% of the entire staff and for 62% of the staff under age 49. This finding aligns with studies that discover narrowed pay gaps between women and men in disciplines in which the participation of women is higher (e.g., Momani et al. 2019). The gender pay gap is particularly wide among technology and engineering graduates.

7. Conclusions and discussion

The research described in this article sheds light on the gender pay gap among researchers at the early stages of their academic careers in Poland. We expected to discover gender equality in the pay of academics, given that the salaries of assistant professors (entry-

level jobs in academia) are regulated. We found that young male researchers earn 4–5% more from their main employment contracts in academia than young female researchers with similar demographic and institutional characteristics. It is of little consolation that this gender pay gap is relatively narrow compared to that in (adjusted) wages for the entire workforce of Poland, which, according to Eurostat estimates, amounts to 12–16%.

Moreover, when we considered that approximately one-third of scientists in Poland hold jobs in addition to their main academic jobs, presumably in both the private and the public sectors, we observed a much wider pay gap between men and women. After all of their sources of labor income are considered, the adjusted gender pay gap reaches 6–11%. Thus, it appears that earnings from outside academia are even more unequal than the basic incomes of male and female researchers.

Parenthood contributes substantially to the gender wage gap in academia, though this effect differs between men and women, and depends on the source of income analyzed. We observed sizeable motherhood wage penalties (i.e. gaps income between mothers and nonmothers) of 18–20% in basic incomes. Simultaneously, we observed no statistically significant differences between the basic incomes of fathers and nonfathers (which stands in contrast to the literature, which typically identifies a fatherhood wage premium). However, the picture changes when total incomes, including those from outside academia, are considered. Not only does a substantial fatherhood wage premium (of 33–37%) emerge, but the motherhood wage penalty also becomes much smaller, or even negative in some of the model specifications.

Several plausible explanations might lie behind the different earning patterns of men and women in Polish academia. Selection could be occurring: men and women who earn only basic incomes in academia might differ in terms of their productivity or abilities from their colleagues who earn additional incomes, which might translate into wider gender pay gaps in total incomes. Moreover, fathers who earn incomes outside academia might constitute a more selected group—one that is more likely to attain such incomes—and that leads to the fatherhood wage premium in total incomes. It is less clear why mothers and nonmothers who receive incomes outside academia exhibit relatively narrow pay gaps (motherhood penalties) compared to mothers and nonmothers with basic incomes only. Again, selection might be a factor. It is unclear to what extent these gender differences are specific to academia, and to what extent they can also be found in other sectors with basic and additional incomes (e.g. doctors, who have both public and private practices). Nevertheless, both for scholars without children, and for mothers and fathers academia appears to be an unequal workplace. This counters its

stereotypical perception of an equal, heavily regulated environment. Additional incomes are one of the dimensions of this inequality.

We also discovered that the effect of gender on income remains stable over time. Among the covariates for which we accounted—individual productivity, whether an institution is public or private, and an institution's quality—only productivity was found to be associated with the salaries earned, and, simultaneously, to correlate with the gender pay gap. Another factor that appears to matter is the field of study: while graduates with engineering and technology degrees earn the highest incomes, the gender pay gaps are also the widest among graduates of that field. Moreover, women aged 40+, as well as women who obtained their PhDs at later ages, earn more than men, all other things equal. Both of these effects are stronger when total income is considered; simultaneously the effect of the feminization of different fields of science was negligible for the gender pay gap. This finding lies in contrast to studies that demonstrate that academics who work in female-dominated fields tend to have lower incomes (Perna 2001; Perna 2003; Smart 1991; Umbach 2007).

We expected academia to be a relatively equal workplace with respect to salaries, as it is influenced by regulated pay-setting procedures and greater pay transparency, and it offers possibilities to combine work and family lives. However, even in such a setting, gender pay inequality arises. The tendency of female researchers to earn less than male ones in the early stages of their careers contributes to the leaky pipeline, with fewer women attaining higher positions and earnings. Additional efforts should be made to attract more female talent into academia and to achieve a more gender-balanced workforce in the sector. This will not be possible without tackling the problem of gender pay inequality. It is also interesting and important to determine whether and, if so, which nonmonetary factors, in addition to greater pay equality, can help women to remain in academia and progress in their careers. Diagnosing the roles of the stereotypes and biases associated with gender norms is another potential step forward.

From a broader perspective, greater pay transparency, which will soon be implemented in European countries (in line with the EU Pay Transparency Directive, approved in 2023 by the European Parliament), has the potential to narrow the gender pay gap through more effective enforcement of the equal pay principle.

Declarations

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Ethical approval

No personal data has been used. All data has been anonymized prior to its access. The data subjects cannot be identified. No vulnerable/special data is used in the analysis. The PI of the project is responsible for adhering to standard ethical and legal procedures.

Competing interests

The authors have no relevant financial or nonfinancial interests to disclose.

Authors' contributions

All authors contributed to the study conception and design. The first draft of the manuscript was written by Iga Magda and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The ELA dataset was designed and created at the National Information Processing Institute, https://opi.org.pl/en/

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