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RESEARCH ARTICLE

Early Career Gender Wage Gap in STEM: New Evidence from Administrative Data

Ksenia V. Rozhkova [1], Sergey Yu. Roshchin [1], Natalya K. Yemelina [1]

1 *HSE University, Moscow, 109028, Russia*

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Abstract

Increasing female representation in technical majors, traditionally associated with high earnings, is recognised as a mechanism for promoting gender equality in the labour market. However, if women quit STEM soon after graduation, increasing their proportion in relevant disciplines will not help reduce the gender wage gap. This paper provides new evidence of the 'leaky pipeline' of women in STEM. Using nationwide administrative data from Russia, it explores recent graduates of 2022 and analyses their educational characteristics, experience of combining study and work, enrolment in postgraduate programmes, and job acquisition one year after graduation.

The results suggest that women are less likely to pursue postgraduate education or to work in STEM-related jobs while at university. One year after graduation, women with STEM degrees are 6 percentage points less likely than men to enter STEM positions as their first post-graduation jobs. Combining study and work in STEM jobs is one of the most significant contributors to the probability of STEM employment after graduation. The highest gender wage gap at career entry is observed among STEM majors employed in STEM jobs (18%), with only about half of this gap explained by observed characteristics. Among non-STEM graduates employed in non-STEM jobs, the gap is statistically insignificant. Among those employed in high-paying technical industries, women experience lower returns to academic excellence and ability.

The results signal not merely gender segregation in STEM education but also implicit gender discrimination in STEM employment, challenging the ability of higher education to promote gender equality in pay.

Keywords

early career, gender wage gap, graduate labour market, school-to-work transition, STEM

JEL codes: J16, J24, J31

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Introduction

Traditionally, a major role in addressing the problem of inequality is attributed to higher education. On the one hand, higher education is a core channel of social mobility, which provides wide opportunities for employment and career fulfilment. On the other hand, the choice of major upon university entry determines lifelong earnings and income disparities (Altonji et al. 2016). Wage gaps between STEM (Science, Technology, Engineering, and Mathematics) and non-STEM graduates remain substantial, with technical and quantitative skills yielding increasingly high earnings premiums (Arcidiacono 2004; Bol and Heisig 2021).

Gender distribution across majors is known to be one of the main contributors to the gender wage gap, both for recent graduates and for more experienced workers (Bobbit-Zeher 2007). In general, women are less likely to major in STEM. In most European countries, the proportion of women in STEM education remains below 30 per cent, although the gap tends to shrink among recent cohorts (VanHeuvelen and Quadlin 2021). While men concentrate in high-paying technical fields, women frequently study humanities or people-centred disciplines, such as education and health, implying employment in relatively low-paying occupations. Recent research suggests that the gender gap in STEM is important for understanding and reducing gender gaps in earnings (Card and Payne 2020), and that increasing female representation in highly paid technical majors may substantially reduce gender inequality in the labour market. However, increasing female representation in STEM majors may not necessarily have a direct impact on the gender wage gap. If female graduates leave STEM upon graduation, then increasing their proportion in relevant disciplines will not help to reduce the gender wage gap. Evidence shows that the transition of female graduates into STEM jobs is limited, with women more likely than men to enter non-STEM occupations (VanHeuvelen and Quadlin 2021). This suggests that the problem is dynamic and requires a more complex approach.

In this study, we describe the gender gap in STEM at different stages of education and early career and explore the resulting gender wage gap among recent graduates, depending on their employment characteristics. We follow the same cohort of university graduates and analyse their experience of combining study and work, enrolment in postgraduate programmes, and job acquisition one year after graduation, providing new evidence of the 'leaky pipeline' of women in STEM. For this purpose, we use administrative data from Russia covering all university graduates who earned their first-cycle degrees in 2022. First-cycle degree programmes in Russia comprise bachelor's and specialist programmes. While bachelor's degrees are the most common and usually take four years to complete, specialist degrees are mostly awarded in medicine, arts, and some engineering fields and take, on average, five years to complete. We also explore a range of educational excellence characteristics, such as honours degree attainment and university selectivity, to control for ability and the quality of education.

There are several contributions of this paper to the literature. First, although labour market entry remains a crucial point in graduate careers, when initial disparities and pay inequalities are being formed, it is studied significantly less frequently (Sassler et al. 2017; Xu 2013) than gender differences in student experiences, including course and major choice (Kugler et al. 2021). Moreover, career entry is particularly convenient for empirical analysis. Recent university graduates majoring in STEM are relatively homogeneous in terms of their educational background, abilities, and limited work experience. Both male and female grad-

uates have similar levels of family responsibilities, which have been widely discussed as a core reason for gender inequality in the labour market (Jasko et al. 2020). Therefore, the observed gender differences in postgraduate education and early career trajectories are more likely to reflect unobserved factors (including discrimination, social pressure, etc.) than objective heterogeneity in human capital accumulation and preferences.

Second, there are only a limited number of studies examining the transition of male and female STEM graduates from university to early career. To our knowledge, this is the first study to analyse students' employment experience in STEM or non-STEM jobs and its impact on early career progression. Third, the existing evidence on gender inequalities in STEM is centred on US data (e.g., Speer 2023; Hunt 2016). Only a limited number of studies come from other countries. One example is the study by Delaney and Devereux (2022) of the UK labour market, showing that women are less likely to enter master's STEM programmes after completing a STEM bachelor's degree and to enter STEM positions as their first job, gradually leaving STEM during the first 15 years after graduation. In our study, we provide evidence from Russia, a country with historically high female participation in the labour force and education.

Literature Review

Gender differences in educational choices

There is a rich literature on gender gaps in STEM major choice and the determinants of course-taking, seeking to explain why the gender distribution across fields of study is so uneven. While there is no gender gap in enrolment in life sciences (Delaney and Devereux 2019; Justman and Mendez 2018), there is a significant male concentration in technology, mathematics, and physics (Delaney and Devereux 2022). Even more importantly, the gender gap in major choice appears to be especially pronounced among high-achieving women (Jiang 2021). Olitsky (2014) shows that high-achieving students receive greater benefits from choosing STEM majors, but among high achievers, males benefit more than females. One possible reason is gender differences in abilities and mathematical skills, but this explanation does not withstand empirical scrutiny (Mann and DiPrete 2013). Moreover, in non-OECD countries, on average, girls score higher in mathematics and science (Reilly et al. 2019). However, girls need stronger prior signals of ability in mathematics to choose male-dominated fields (Justman and Mendez 2018). This issue arises from gender differences in self-concept, self-efficacy, and confidence in one's abilities, with girls reporting lower self-efficacy beliefs when it comes to mathematics (Reilly et al. 2019).

Gender-based differences in STEM may originate from gendered stereotypes, culture, and interests, starting in early childhood, becoming stronger at school, and eventually solidifying on the verge of higher education (Kahn and Ginther 2017). For instance, women are more likely to choose their major based on interest rather than as a strategic career decision (Mann and DiPrete 2013) and are less likely than men to consider salary a decisive factor (Jasko et al. 2020). Moreover, stereotypes concerning 'male' and 'female' majors still prevail, suggesting that men are perceived as better at understanding physical laws and more inclined towards a technical and logical mindset, while women are perceived as more diligent and hardworking (Maloshonok et al. 2022).

Once the choice to pursue a STEM degree is made, women are more likely than men to change their educational trajectory. This is generally reflected in three forms: dropout,

switching out of a major during undergraduate studies, and switching majors for a master's degree. While some researchers suggest that university attrition in STEM is similar for men and women (Kugler et al. 2021), others report substantial differences, with women dropping out more often (Isphording and Qendrai 2019). When multiple signals of 'lack of fit' in STEM fields occur (low grades, peer composition, etc.), women also tend to switch out of their major (Kugler et al. 2021). Even after completing their undergraduate studies in STEM, women are more likely than men to switch their major for a master's degree and study non-STEM disciplines (Delaney and Devereux 2022).

'School-to-work' transition of STEM graduates and the gender wage gap

In many countries, women with STEM majors demonstrate employment patterns that resemble those of men with non-STEM majors rather than those of men with STEM majors (VanHeuvelen and Quadlin 2021). Right after graduation, women with STEM credentials experience more difficulties in finding a job, receive fewer job offers, earn lower wages, and are less likely to find a job matching their skills (Jasko et al. 2020).

Women are less likely than men to enter STEM jobs and are less likely to remain in those jobs if they do (Xu 2013). Immediately after labour market entry, the gender gap in STEM employment is already 10 percentage points, increasing to 25 percentage points over 15 years (Delaney and Devereux 2022). Hunt (2016) suggests that women are more likely than men to leave engineering fields but not the sciences. Importantly, controlling for family characteristics does not change the observed gender gap in STEM employment (Sassler et al. 2017). Due to family responsibilities, women may prefer jobs that offer a better work-life balance and predictable working hours. Kahn and Ginther (2015) suggest that a lack of part-time work opportunities drives women out of engineering occupations. However, women majoring in STEM disciplines who are career-oriented and expect to marry later are no more likely to enter STEM jobs than women who prioritise family (Sassler et al. 2017). Having children before graduation or at labour market entry is not a significant contributor to the STEM employment gap among engineering and computer science graduates (Schwerter and Ilg 2023).

Some studies suggest that women with STEM degrees tend to major in less maths-intensive fields, making non-STEM jobs a good match for their skills (Jiang 2021). Different types of universities may also affect job-education matches in STEM (Xu 2013). In terms of university selectivity, some studies show that it is irrelevant for labour market outcomes among STEM majors, in contrast to non-STEM fields (Eide et al. 2015). Kim and colleagues (2021) suggest that STEM graduates from highly selective universities enjoy greater career benefits and are more likely to be employed in related jobs. However, even when graduating from highly selective universities, female graduates in STEM disciplines have lower remuneration than their male counterparts. Recent research suggests that while males in STEM majors benefit from graduating from selective universities, females do not (Quadlin et al. 2021). This difference in returns may reflect lower expectations of female performance, indicating possible discrimination.

A sizable gender wage gap persists in STEM occupations (VanHeuvelen and Quadlin 2021). Without additional controls for confounding variables, there is an almost 30 per cent gender wage gap in STEM in the US labour market among those working full time. Controlling for educational and personal characteristics, as well as family variables, reduc-

es the observed gap to 15 per cent (Kahn and Ginther 2017). In Canada, the gender wage gap is the smallest among liberal arts graduates and the largest among graduates in maths, computer science, engineering, and other technical fields (Jehn et al. 2021). Only a limited number of studies explore the gender wage gap among STEM graduates during their early careers.

Russia represents an especially interesting setting for the study of the early-career gender wage gap for several reasons. First, Russia is a country with high female participation in higher education and the labour force. However, the gender wage gap remains highly pronounced in the labour market: on average, the gap in mean monthly earnings is estimated at 30–35 per cent among the working population (Oshchepkov 2021). Second, horizontal job segregation, which often results from the choice of university major, is a key contributor to the observed wage gap, explaining approximately 45 per cent of it (Oshchepkov 2021). Third, although there are many studies exploring the Russian graduate labour market and wage differentiation due to various educational characteristics, less is known about differences in returns to majors overall and to STEM majors in particular. Previous studies suggest that there is a high selectivity premium during early career (Rozhkova et al. 2023), as well as a high premium for combining study and work (Rozhkova et al. 2024a). Combining study and work is not only a widespread phenomenon, with more than half of the student population working during their studies, but is also a significant stage of early professionalisation. Regarding the early-career gender wage gap in Russia, previous studies have shown that the gap among university graduates is already present six months after graduation, amounting to 14 per cent, and rises dramatically to 29 per cent three years after graduation. Moreover, there is a strong glass ceiling effect from the very beginning of graduate careers (Rozhkova et al. 2024b).

Data and method

Data

The data for our study come from the federal project 'Monitoring of Graduate Employment', which is jointly conducted by the Ministry of Labour and Social Security of the Russian Federation and the Federal Service for Labour and Employment. The monitoring covers individuals graduating from all educational levels since 2016, including middle and high schools, vocational training institutions, universities, and postgraduate programmes. Each educational institution is obliged to transfer data on all issued diplomas to the Federal Registry of Educational Documents. The data contain, among other parameters, the field of study, the name of the educational organisation, the type and level of the completed programme, and the source of funding. This information is further transferred to the Social Fund of Russia, where it is merged with monthly data on employment and socio-demographic characteristics using a unique social security number. Employment characteristics include industry, occupation, region of employment, period of employment, and monthly after-tax wages. As a result, the 'Monitoring of Graduate Employment' enables us to follow educational, career, and migration trajectories within the country at the micro level for all graduates.

For this study, we explore a cohort of bachelor's and specialist degree holders who studied in full-time programmes at Russian universities, graduated in 2022, and were under 30 years of age at the time of graduation. For those graduates who continued their studies in master's

programmes, we also explore majors and gender composition. Early career outcomes are assessed during the first post-graduation year in the labour market. This results in a total sample of 319,288 graduates, of whom 112,921 majored in STEM disciplines. Tables 1A and 2A in Supplementary material summarise the main descriptive statistics for the sample of STEM and non-STEM graduates by gender.

Although this is a unique dataset covering the entire graduate population, it has two main limitations. First, data on occupations are available only from June 2021. Therefore, our analysis of the job structure while combining study and work is limited to the senior year of university. Second, since these are administrative data, we lack information on hours worked and background characteristics.

Method

We should define which majors and jobs are considered STEM within the framework of our analysis, since a great deal of the heterogeneity in existing research findings can be explained by different approaches to these definitions. Relying on the national system of educational domains ('Russian Classification of Professions by Education'), we define STEM majors as degrees obtained in Mathematics and Computer Sciences, Life Sciences (comprising Physics and Astronomy, Chemistry, Geography, and Biology), and Engineering (see Table 3A in Supplementary material). Other fields of study are considered non-STEM. In turn, STEM jobs are codified according to the Russian Classification of Occupations, which is largely in line with the well-established International Standard Classification of Occupations (ISCO-08) (see Table 4A in Supplementary material. The remaining jobs are considered non-STEM.

First, we analyse descriptive evidence on the gender distribution across STEM and non-STEM graduates, their transition to postgraduate education, and the incidence of combining study and work during undergraduate studies, by gender. Graduates obtaining bachelor's and specialist's degrees in 2022 could enter full-time postgraduate programmes either in 2022 or 2023, and our data allow us to track such entries. When reporting the percentage of graduates who had labour market experience prior to graduation, we count all students who had at least one month of paid work from September 2019 to June 2022 for bachelor's degree holders and from September 2018 to June 2022 for specialist's degree holders. When reporting whether student employment was in a STEM or non-STEM job, we focus only on employment during the final academic year, 2021/2022, due to the lack of reliable occupation data for earlier periods.

Second, we estimate a set of probit models to identify the determinants of STEM and non-STEM employment after graduation for male and female graduates. The model can be written as:

$$\Pr\left(Y_i = 1 \mid X_i\right) = \Phi\left(X_i^T \beta\right), \tag{1}$$

where Y is a binary outcome variable, that equals 1 if the graduate is employed in a STEM job, and 0 otherwise, $\Phi(.)$ represents the standard normal cumulative distribution function, X is a vector of explanatory variables, β are the corresponding coefficients, i denotes the observations. The model is estimated separately for male and female graduates and for STEM and non-STEM graduates.

The explanatory variables can be divided into three groups. The first group includes the type of programme (a binary variable equal to 1 for specialist's degree holders and 0 for bachelor's degree holders) and major (a categorical variable that includes Mathematics and

Computer Sciences, Life Sciences, and Engineering for STEM graduates, and Agriculture, Social Sciences, Health, Education, Humanities, and Arts for non-STEM graduates).

The second group of explanatory variables is related to educational quality. These variables include: 1) achievement at high school as a measure of cognitive ability (a binary variable equal to 1 in the case of an honours diploma and 0 otherwise); 2) academic achievement at university (a binary variable equal to 1 in the case of an honours degree and 0 otherwise); 3) the level of university selectivity (a binary variable equal to 1 in the case of a selective university and 0 otherwise). The measure of university selectivity is based on the average score on the Unified State Examination for one exam among enrolled students. Each exam is graded on a 100-point scale. Universities with a score above 80 are considered selective. The average score is obtained from the Monitoring of Enrolment Quality (HSE University, n.d.); and 4) experience of combining study and work (a categorical variable that includes combining study with work in a STEM job, combining study with work in a non-STEM job, or no pre-graduation work experience as the reference category).

The third group comprises job controls: region of work, to account for interregional heterogeneity, and enterprise size based on the number of employees (a categorical variable including small, medium, and large enterprises, with micro enterprises as the reference category). We additionally control for age at the time of graduation.

Third, we estimate a Mincer-type wage equation, which can be written as:

$$\mathrm{In}\left(W_i\right) = X_i^T\beta + \varepsilon_i, \tag{2}$$

where W is the average monthly wage, calculated as the sum of earnings, received from July 2022 to June 2023 after taxation, divided by the number of months worked. X is a vector of explanatory variables, β are the corresponding coefficients, ε is the error term, i indexes observations.

The set of explanatory variables includes age, type of programme, major, honours diploma at school, honours degree at university, experience of combining study and work, occupation (a categorical variable used to control for vertical segregation, including nine categories: Managers, Professionals, Technicians and Associate Professionals, Clerical Support Workers, Service and Sales Workers, Skilled Agricultural Workers, Craft and Related Trades Workers, Plant and Machine Operators, and Elementary Occupations as the reference category), industry (a categorical variable based on the International Standard Industrial Classification of All Economic Activities (ISIC-4), with 18 categories in total and Information and Communication as the reference category), enterprise size, and region of work. The wage equation is estimated separately for male and female samples and for four types of major-job combinations: 1) STEM education + STEM job; 2) STEM education + non-STEM job; 3) non-STEM education + STEM job; and 4) non-STEM education + non-STEM job.

Finally, we use the traditional decomposition method proposed by Oaxaca (1973) and Blinder (1973) and modified by Neumark (1988) to establish the contribution of each explanatory variable to the gender wage gap. The modification enables the wage gap to be interpreted independently of the reference wage structure. The decomposition equation can be written as:

$$\mathrm{In}\left(\overline{W_m}\right) - \mathrm{In}\left(\overline{W_f}\right) = \left(\overline{X_m} - \overline{X_f}\right)\hat{\beta}_t + \overline{X_m}\left(\hat{\beta}_m - \hat{\beta}_t\right) + \overline{X_f}\left(\hat{\beta}_f - \hat{\beta}_t\right), \tag{3}$$

where $\overline{W_m}$ and $\overline{W_f}$ are the wages of male and female graduates, respectively, $\overline{W} = \exp\frac{1}{n}\left[\sum_{i=1}^{n}\mathrm{In}\left(W_i\right)\right]$ represents the geometric mean wage of n individuals, $\overline{X_m}$ and $\overline{X_f}$

are the mean explanatory variables for males and females, respectively, $\hat{\beta}_m, \hat{\beta}_f, \hat{\beta}_t$ are the estimated coefficients for the male, female, and pooled samples, respectively, i indexes observations.

Therefore, on the left-hand side of the equation, we have the difference in log wages earned by male and female graduates, while on the right-hand side, this difference is decomposed into the part explained by gender differences in observed characteristics (the so-called endowment effect) and the unexplained part, which may reflect gender differences in returns to these characteristics.

Results

Gender composition across the field of study: undergraduate degrees and transition to graduate education

STEM is the largest field of education in Russia, with 35 per cent of graduates obtaining degrees in these fields. Although women prevail in higher education, with 57 per cent of degrees awarded to female graduates in 2022, only 37 per cent of female graduates obtain degrees in STEM majors. Of the three broad STEM fields, the most common is Engineering (66 per cent of all awarded STEM degrees), followed by Mathematics and Computer Science (23 per cent) (Table 1A in Supplementary material). At the same time, Mathematics and Computer Science and Engineering are the highest-paying majors in Russia, with average monthly wages of 64.5 and 49.8 thousand roubles, respectively, during the first post-graduation year in the labour market. Life Sciences appears to be simultaneously the least popular STEM major and the only one in which women prevail, with 61 per cent of degrees awarded to women. In contrast, only 28 per cent of degrees in Mathematics and Computer Science and 36 per cent of degrees in Engineering are obtained by female graduates. The average monthly wage for graduates in Life Sciences is 41.6 thousand roubles.

STEM graduates are more likely to continue their education in postgraduate programmes. On the one hand, this may be explained by the complexity of study programmes, which require more time to master the profession. On the other hand, many jobs in STEM are in science, where a PhD serves as a prerequisite but cannot be acquired without completing a master's programme. Forty-one per cent of STEM graduates pursue a master's degree, compared with 19 per cent of non-STEM graduates. From a gender perspective, male STEM graduates tend to continue their education more often than female graduates (43 per cent compared with 37 per cent). Moreover, STEM bachelor's degree holders tend to remain within their chosen educational field and generally pursue a master's degree in STEM: in both the male and female samples, 94 per cent of STEM graduates who pursue a master's degree major in STEM.

Regarding ability and educational quality, women demonstrate a significantly better academic record than men: among STEM graduates, 25 percent of females had an honours diploma in high school compared to only 10 percent among males. The distribution persists at the university level: 27 percent of female graduates received an honours diploma, while only 12 percent of male graduates achieved the same result. Both men and women are equally presented in the top selective universities (6 percent each). Therefore, we can conclude that differences in abilities or educational quality are likely to play in favour of women in early labour market results.

Gender differences in 'school-to-work' transition among STEM and non-STEM graduates

Moving from educational trajectories to labour market transitions, we first discuss the pre-graduation work experience acquired by STEM graduates. First, our data suggest that combining study and work is a widespread phenomenon among Russian full-time university students, with 58 per cent of both men and women having at least one month of such experience during their studies. This finding is consistent with previous research on the topic (Rozhkova et al. 2024a). At the same time, STEM students are slightly more likely to combine study and work than students with non-STEM majors. One possible explanation is that technical fields require more practical skills, which may be best developed in a real-world work environment. Although male and female STEM graduates were equally likely to be employed while studying, the types of jobs they held differed significantly (Table 1). Men majoring in Mathematics and Computer Science were significantly more likely than their female counterparts to work in STEM jobs (24 per cent vs 18 per cent). The same applies to Life Sciences majors (17 per cent vs 11 per cent, respectively).

Gender differences in distribution across jobs persist after graduation as well (Table 2). While 63 percent of male STEM graduates are employed in STEM jobs one year after graduation, only 55 percent of female STEM graduates are employed in them. Among non-STEM degree holders, males are also more likely to be employed in STEM jobs than females (10 percent versus 6 percent, respectively). However, diving into STEM fields of study brings some interesting insights. For instance, women are 10 percentage points less likely to work in STEM jobs if they major in Mathematics and Computer Science (48 percent among males vs 38 percent among females) but only 4 percentage points less likely if they major in Life Sciences (36 percent vs 32 percent, respectively). However, among Engineering graduates, women are almost 7 percentage points more likely to be employed in STEM jobs one year after graduation. This result contrasts with the existing evidence for the US, where women are more likely than men to avoid engineering fields but not sciences (Hunt 2016).

Table 1. Pre-graduation employment experience of higher education graduates by gender and field of study, per cent

	Male graduates				Female graduates			
	STEM majors			Non-STEM majors	STEM majors			Non-STEM majors
	Mathematics and Computer science	Life Sciences	Engineering		Mathematics and Computer science	Life Sciences	Engineering	
Combined study and work (at least one month during the entire study period)	57.0	56.3	58.5	49.8	59.2	52.2	59.4	54.9
Combined study and work in STEM jobs during the senior year	23.7	17.1	14.8	2.1	18.3	11.0	15.6	1.4
Combined study and work in non-STEM jobs during the final year of study	9.5	13.1	15.6	21.2	14.9	14.7	15.4	24.7

Table 2. Distribution of higher education graduates across occupations by major and gender, per cent

	STEM majors						Non-STEM majors	
	Mathematics and Computer science		Life Sciences		Engineering			
	Male	Female	Male	Female	Male	Female	Male	Female
STEM high-skilled white-collar occupations	41.8	32.8	28.9	24.9	29.4	36.7	3.6	2.9
STEM low-skilled white-collar occupations	5.7	4.9	6.9	7.4	6.8	5.8	1.1	0.8
Non-STEM occupations	52.5	62.3	64.2	67.7	63.8	57.5	95.3	96.3
Total	100	100	100	100	100	100	100	100

Gender distribution across industries may also be a significant contributor to the gender wage gap, complementing occupational differences (Table 5A in Supplementary material). Our data suggest that, irrespective of field of study, male STEM graduates are more represented in the high-paying Information and Communication industry, especially among Mathematics and Computer Science majors (49 per cent compared with 38 per cent among females), and in Professional, Scientific and Technical Activities, but only among Life Sciences majors (33 per cent compared with 25 per cent among females). Females are significantly more commonly represented in Trade and Education, two industries that are usually associated with lower pay.

Table 3 presents the regression results for the probability of being employed in STEM jobs for STEM and non-STEM graduates one year after graduation. First, male STEM graduates are 6 percentage points more likely than female STEM graduates to enter STEM jobs, while among non-STEM graduates, the difference is smaller, at approximately 3 percentage points. In terms of fields of study, contrary to previous research, Life Sciences majors are the least likely to enter STEM employment after graduation. Female Engineering and Mathematics and Computer Science majors have 8 and 3 percentage points higher probabilities of being employed in STEM jobs, respectively, compared with Life Sciences majors. For male STEM graduates, Mathematics and Computer Science majors have the highest probability of STEM employment, with an 8 percentage point higher probability than Life Sciences majors, while the difference between Engineering and Life Sciences is statistically insignificant.

Second, academic achievement is associated with a higher probability of STEM employment for both male and female STEM graduates, with a high school honours diploma increasing the probability by approximately 3 percentage points in both groups. However, a university honours degree has a stronger association with STEM employment among males, increasing the probability by 5 percentage points, compared with only 1 percentage point for females. Graduating from a selective university is associated with a 2 percentage

point lower probability of STEM employment among males, while the association is statistically insignificant among females.

Third, interesting results concern the characteristics of combining study with work. Having pre-graduation work experience in STEM is associated with a 29-percentage point higher probability of entering a STEM job for males and a 34-percentage point higher probability for females, compared with graduates with no prior work experience. In contrast, having a non-STEM job while studying is associated with a 34-percentage point lower probability of entering a STEM job afterwards for males and a 29-percentage point lower probability for females, compared with those with no pre-graduation work experience. Thus, combining study and work is the strongest predictor of STEM employment.

For non-STEM graduates, entering STEM jobs is relatively rare. Academic achievement has little substantive association with STEM employment: for male graduates, neither a high school honours diploma nor a university honours degree is statistically significant, while for female graduates, both effects are statistically significant but economically small. Graduating from a selective university is associated with a 1 percentage point higher probability of entering a STEM job for female non-STEM graduates, while the effect is statistically insignificant for males. However, the most important contributor to this probability, similarly to STEM graduates, is combining study and work in STEM jobs during university studies. It is associated with a 58-percentage point higher probability of post-graduation STEM employment for males and a 50-percentage point higher probability for females, compared with graduates without student employment experience. Those with student jobs outside STEM are less likely to enter STEM jobs after graduation: the probability is 5 percentage points lower among males and 3 percentage points lower among females.

Table 3. Probability of being employed in STEM jobs by gender and major: marginal effects from probit models

	STEM graduates			Non-STEM graduates		
	Total sample	Male sample	Female sample	Total sample	Male sample	Female sample
Male (base = female)	0.0614***			0.0265***		
	(0.0036)			(0.0017)		
Age	-0.0026	-0.0025	-0.0016	-0.0022**	-0.0023	-0.0025**
	(0.0020)	(0.0025)	(0.0035)	(0.0009)	(0.0019)	(0.0009)
Specialist's degree (base = bachelor's degree)	0.0235***	0.0154**	0.0482***	-0.0191***	-0.0152***	-0.0185***
	(0.0055)	(0.0067)	(0.0095)	(0.0020)	(0.0051)	(0.0022)
STEM major (base = Life Sciences)						
Mathematics and Computer Sciences	0.0805***	0.0844***	0.0296***	-	-	-
	(0.0063)	(0.0094)	(0.0093)			
Engineering	0.0435***	-0.0081	0.0793***	-	-	-
	(0.0056)	(0.0090)	(0.0074)			

	STEM graduates			Non-STEM graduates		
	Total sample	**Male sample**	**Female sample**	**Total sample**	**Male sample**	**Female sample**
Non-STEM major (base = Social Sciences)						
Health	-	-	-	-0.0206***	-0.0471***	-0.0129***
				(0.0025)	(0.0052)	(0.0028)
Agriculture	-	-	-	0.1272***	0.1504***	0.1225***
				(0.0049)	(0.0091)	(0.0060)
Education	-	-	-	-0.0271***	-0.0264***	-0.0239***
				(0.0017)	(0.0055)	(0.0017)
Humanities	-	-	-	-0.0143***	-0.0226***	-0.0112***
				(0.0022)	(0.0054)	(0.0023)
Arts	-	-	-	0.1129***	0.0378***	0.1240***
				(0.0058)	(0.0123)	(0.0063)
High school honours diploma (base = no)	0.0301***	0.0295***	0.0345***	0.0042**	0.0029	0.0041**
	(0.0047)	(0.0070)	(0.0064)	(0.0020)	(0.0065)	(0.0020)
University honours degree (base = no)	0.0325***	0.0541***	0.0124**	0.0026	0.0024	0.0028*
	(0.0043)	(0.0062)	(0.0059)	(0.0016)	(0.0047)	(0.0016)
Selective university (base = no)	-0.0086	-0.0206**	-0.0012	0.0110***	0.0114	0.0113***
	(0.0075)	(0.0097)	(0.0119)	(0.0031)	(0.0071)	(0.0034)
Combined study with STEM job (base = no pre-graduation employment)	0.3133***	0.2886***	0.3405***	0.5267***	0.5842***	0.5014***
	(0.0035)	(0.0043)	(0.0059)	(0.0094)	(0.0143)	(0.0121)
Combined study with non-STEM job	-0.3233***	-0.3429***	-0.2885***	-0.0379***	-0.0535***	-0.0329***
	(0.0046)	(0.0061)	(0.0069)	(0.0013)	(0.0031)	(0.0013)
Size of the enterprise (base = micro)						
Small	0.0260***	0.0372***	0.0143	0.0003	-0.0016	0.0013
	(0.0066)	(0.0087)	(0.0101)	(0.0023)	(0.0060)	(0.0024)
Medium	0.0059	0.0090	0.0043	-0.0024	0.0008	-0.0025
	(0.0076)	(0.0099)	(0.0117)	(0.0025)	(0.0068)	(0.0026)
Large	-0.0107*	-0.0303***	0.0242***	0.0146***	-0.0007	0.0196***
	(0.0059)	(0.0079)	(0.0092)	(0.0022)	(0.0055)	(0.0023)
Region of work	+	+	+	+	+	+
N	68612	40213	28399	111992	27550	84442

Note: *p < 0.1; **p < 0.05; ***p < 0.01

Wage equations results

Basic wage equations provide some insight into gender differences in returns to various educational and job characteristics (Table 4). Male STEM graduates generally enjoy higher returns to Mathematics and Computer Science (31 per cent) and Engineering (16 per cent) majors than their female counterparts (29 per cent and 13 per cent, respectively). They also demonstrate higher returns associated with ability, academic achievement, and educational quality: a high school honours diploma is associated with an additional 7 per cent wage premium for males, compared with 5 per cent for females, while a university honours degree is associated with a 4 per cent premium for males and 2 per cent for females. Moreover, men receive significantly higher returns to combining study with work, both in STEM jobs (34 per cent compared with 23 per cent for female graduates) and in non-STEM jobs (19 per cent compared with 13 per cent, respectively).

Separate wage regressions for four different major–job combinations suggest that, controlling for various educational and job characteristics, STEM employment is associated with the largest gender wage penalty. Mathematics and Computer Science is the highest-paying STEM major, followed by Engineering, irrespective of the type of job. Even when employed in non-STEM jobs, Mathematics and Computer Science and Engineering majors earn 14 per cent and 6 per cent more than Life Sciences majors, respectively. Educational quality and ability variables demonstrate a stable positive association with wages for graduates across all types of employment. However, while the returns to academic achievement (at both school and university levels) are relatively stable (5–6 per cent for a high school honours diploma and 2–3 per cent for a university honours degree), returns to university selectivity vary considerably across major–job combinations. Among STEM graduates employed in STEM jobs, graduating from a selective university is associated with an approximately 5 per cent wage premium, while the premium is approximately twice as high among those employed in non-STEM jobs. For non-STEM majors, the return is even higher, at approximately 16 per cent in both STEM and non-STEM employment. This result is partly consistent with the literature suggesting that university selectivity is less relevant to the remuneration of STEM graduates (Eide et al. 2015).

The strongest predictor of wages is combining study and work, especially when this experience is gained in STEM jobs. Interestingly, having work experience in STEM while studying is associated with a substantial wage premium not only among STEM graduates working in STEM jobs, but also among those who move into non-STEM employment and among non-STEM graduates in both types of jobs. This positive association may arise for several reasons. First, since STEM jobs are mostly skill-intensive, such experience may be valuable in many occupations outside formal STEM employment (for example, for economists or financial analysts). Second, companies providing STEM jobs may be perceived as more technologically advanced, and experience with such employers may send a positive productivity signal to prospective employers, particularly at the early stages of a career. Third, the jobs that we define as STEM require high qualifications and may involve creativity, analytical and structured thinking, and other skills that can serve as strong signals of ability in subsequent employment, irrespective of major and type of job.

Table 4. Wage equation results by gender, OLS regression coefficients for selected variables

	Male sample	Female sample	STEM major + STEM job	STEM major + non-STEM job	Non-STEM major + STEM job	Non-STEM major + non-STEM job
Education major						
Mathematics and Computer Sciences	0.2749***	0.2532***	0.2561***	0.1272***	-	-
Engineering	0.1485***	0.1281***	0.1223***	0.0584***	-	-
Life Sciences	Base outcome	Base outcome	Base outcome	Base out-come	-	-
Health	-0.0016	0.1559***	-	-	0.0131	0.0381***
Agriculture	0.0162	-0.0131	-	-	-0.1158***	-0.1282***
Social Sciences	0.1008***	0.1390***	-	-	Base out-come	Base out-come
Education	0.2158***	0.2183***	-	-	-0.0446	0.0444***
Humanities	0.1330***	0.0772***	-	-	-0.2298***	-0.0615***
Arts	0.0696**	0.0913***	-	-	-0.0367	-0.0634***
High school honours diploma (base = no)	0.0670***	0.0489***	0.0446***	0.0654***	0.0446**	0.0521***
University honours degree (base = no)	0.0392***	0.0226***	0.0319***	0.0252**	0.0284*	0.0236***
Selective university (base = no)	0.1219***	0.1219***	0.0493***	0.0920***	0.1530***	0.1496***
Combined study with STEM job (base = no pre-graduation employment)	0.3049***	0.2224***	0.2316***	0.2098***	0.2732***	0.1857***
Combined study with non-STEM job	0.1650***	0.1195***	0.0960***	0.1830***	0.1148***	0.1336***
N	67822	112843	41255	27362	7822	104226
R^2_{adj}	0.2815	0.2700	0.3307	0.2712	0.2859	0.2466

Note: *p < 0.1; **p < 0.05; ***p < 0.01; Full results are presented in Tables 6A-7A in Supplementary material

Early career gender wage gap among STEM and non-STEM graduates

Finally, we explore the gender wage gap and its decomposition among university graduates during the first year after graduation. In Table 5, we report the results for the four separate major–job combinations, along with those of a baseline model estimated on the total sample for comparison.

Table 5. The contribution of various factors to the explanation of the gender wage gap by major and job

	All graduates	STEM major + STEM job	STEM major + non-STEM job	Non-STEM major + STEM job	Non-STEM major + non-STEM job
$\ln(\overline{W_m}) - \ln(\overline{W_f})$	0.1451***	0.1683***	0.1635***	0.074***	0.0064
Explained (composition effect)	0.0978***	0.0673***	0.1060***	-0.0059	0.005*
Unexplained (returns effect)	0.0473***	0.1010***	0.0575***	0.0798***	0.0014
Explained:					
Age	0.0009***	0.0025***	0.0028***	-0.0007	0.0009***
Bachelor's or specialist's degree	-0.0016***	0.0060***	0.0123***	-0.0008	0.0001
STEM major	0.0046				
STEM job	0.0216***				
Major	-0.0048	0.0026***	0.0025*	-0.0008	-0.0075***
High school diploma with honours	-0.0064***	-0.0083***	-0.0099***	-0.0061**	-0.0061***
University degree with honours	-0.0044***	-0.0056***	-0.0047***	-0.0068**	-0.0037***
Selective university	0.0012***	0.0003**	0.0003	-0.0014	0.0006**
Combining study and work	0.0041***	0.0034***	0.0028***	0.0058***	0.0012***
Job	0.0052***	-0.0020***	0.0184***	-0.0054**	-0.0222***
Industry	0.0391***	0.0462***	0.0523***	0.0164***	0.0112***
Size of the enterprise	0.0145***	0.0084***	0.0159***	-0.0020	0.0087***
Region of work	0.0237***	0.0139***	0.0130***	-0.0039	0.0217***
Unexplained					
Age	0.4513	0.2994*	0.5485***	0.0477	0.2369*
Bachelor's or specialist's degree	0.0652***	0.0033	-0.1000***	-0.0657	-0.0063
STEM major	0.0734***				
STEM job	0.0168***				
Major	-0.0397***	-0.0524***	-0.0205	0.0441	-0.0412***
High school diploma with honours	0.0021*	0.0074**	-0.0031	0.0063	0.0010

	All graduates	STEM major + STEM job	STEM major + non-STEM job	Non-STEM major + STEM job	Non-STEM major + non-STEM job
University degree with honours	0.0039**	0.0053	0.0122***	-0.0247***	0.0013
Selective university	0.0019**	0.0069***	0.0033	0.0072	0.0025*
Combining study and work	0.0102***	0.0207***	-0.006	0.0073	0.0058*
Job	-0.0249***	0.0833**	-0.0392***	0.0536	-0.0203*
Industry	-0.0058	-0.0075	-0.0013	0.0410**	-0.0148**
Size of the enterprise	-0.0048**	-0.0009	0.0264***	-0.0005	-0.0056
Region of work	-0.0230***	-0.0202	-0.0267**	0.0160	-0.0220***
Constant	-0,4793	-0,2445	-0,3360*	-0,0525	-0,1358
N	180665	41255	27362	7822	104226

Note: *p < 0.1; **p < 0.05; ***p < 0.01

For the total sample (Column 1), the raw gender wage gap one year after graduation is already 15.6 per cent, with 79 per cent of the gap explained by observed differences in educational and job characteristics. Job characteristics taken together (region of work, enterprise size, occupation, and industry) explain roughly half of the observed wage disparity. However, the separate major–job combinations have their own distinctive features.

First, STEM majors employed in STEM jobs (Column 2) have the largest gender wage gap among the four major–job combinations. The raw gap one year after graduation is already 18 per cent, only slightly higher than the gap for the total sample. However, the explained component of the gap is substantially smaller than in the baseline model, with only 54 per cent attributable to observed gender differences in characteristics. The largest contributor to the explained gap is the gender distribution across industries (almost 20 per cent), followed by the field of study within STEM (18 per cent). The growing labour market for IT specialists provides employment opportunities primarily for Mathematics and Computer Science graduates. Engineers are also able to enter these occupations due to their strong mathematical skills. Life Sciences, however, generally differ in terms of mathematical intensity. This result is consistent with existing studies from other countries, suggesting that detailed controls for field of study are important and can explain a significant portion of the STEM gender wage gap after labour market entry (Delaney and Devereux 2022). Academic achievement and university selectivity reduce the explained component of the gap by almost 7 per cent. However, their contribution to the unexplained component is substantially larger, highlighting pronounced differences in returns to ability and academic achievement between men and women. Finally, combining study and work explains an additional 7 per cent of the observed wage gap.

Second, among non-STEM majors employed in STEM jobs (Column 4), the raw gender wage gap decreases by more than half, reaching 7.7 per cent. The gap is not explained by the observed characteristics, with the entire gap attributable to differences in estimated returns. This evidence, combined with the findings for STEM majors, suggests the presence of substantial gender disparities in returns within STEM employment, which may be consistent with gender discrimination.

Third, STEM majors employed in non-STEM jobs experience a sizable raw gap of 17.8 per cent. However, the proportion of the gap explained by observed characteristics is larger than in the 'STEM major–STEM job' case and is close to that for the total sample (75 per cent). Gender distribution across industries (33 per cent of the explained gap) and occupations (12 per cent) are both more important explanatory factors than field of study (5 per cent). Academic variables demonstrate a similar pattern to that observed in the 'STEM major–STEM job' case.

Finally, non-STEM majors employed in non-STEM jobs do not experience a statistically significant gender wage gap one year after graduation. Therefore, the results point to a situation of 'equality in poverty' alongside widening inequality towards the top of the income distribution, particularly in technologically advanced jobs and among workers with modern human capital and high-demand skills. The widening gender wage gap towards the upper part of the wage distribution, irrespective of occupational structure, is commonly referred to as the glass ceiling effect in the labour market. Our results suggest that such a pattern is already observable among Russian STEM graduates one year after graduation.

Discussion

Our results are consistent with recent research (Quadlin et al. 2021; Sassler et al. 2017; VanHeuvelen and Quadlin 2021) and suggest that increasing policy efforts to change the gender distribution across STEM majors has limited potential to reduce the gender wage gap and the gender gap in STEM employment. The 'leaky pipeline' of women in STEM exists in Russia, as in other countries (Delaney and Devereux 2022), although the proportion of female graduates eventually obtaining STEM degrees from Russian universities (37 per cent) is somewhat higher than that reported for Europe (VanHeuvelen and Quadlin 2021). Women are significantly underrepresented in high-paying fields such as Computer science and Engineering, while they are overrepresented in the less well-paid Life sciences. The process of leaving STEM occurs gradually among female graduates: women are 6 percentage points less likely than men to continue their education in postgraduate programmes, 2 percentage points less likely to have a STEM job during their senior year at university, and 8 percentage points less likely to be employed in STEM during the first year after graduation. We expect an even greater degree of career switching as careers progress, as shown by Delaney and Devereux (2022) for the UK.

An unexpectedly large gender wage gap among STEM graduates entering STEM employment may be one of the factors contributing to women's lower likelihood of pursuing STEM careers. Rather than reducing gender inequality in the labour market, STEM occupations may reinforce it, as almost half of the observed gap remains unexplained by differences in endowments, even after controlling for various characteristics, including a proxy for ability. This may be consistent with unobserved discrimination, as suggested by substantial gender differences in returns to educational and job characteristics. In particular, high-achieving men receive greater wage returns to their abilities and academic achievements than high-achieving women. Similar findings have been reported for other countries (Quadlin et al. 2021; Kim et al. 2021).

Another important finding concerns the contribution of combining study and work to the subsequent career trajectories of university graduates. Previous research has shown that student employment enhances the career opportunities of university graduates by increasing

wages and improving job matching while reducing the probability of unemployment (Passaretta and Triventi 2015), but this phenomenon has received less attention in the context of STEM. Our results suggest that having a STEM job during the senior year at university is one of the strongest predictors of post-graduation STEM employment for both STEM and non-STEM majors, while having pre-graduation work experience in a non-STEM job significantly reduces the likelihood of STEM employment. Moreover, student employment in STEM is associated with higher wages among both STEM and non-STEM majors employed in both STEM and non-STEM jobs. This raises questions about the importance of combining study and work as a source of practical skills and early professionalisation in STEM.

Conclusion

This study explores the early-career outcomes of STEM graduates, including combining study and work, the 'school-to-work' transition, and the gender wage gap one year after graduation, based on rich administrative data from Russia. Although increasing female representation in STEM majors is often considered a potential mechanism for reducing gender inequality in the labour market, our results suggest that this policy alone may have limited effects. First, women are less likely than men to have a STEM job while still at university and are 6 percentage points less likely to enter STEM positions as their first post-graduation jobs. Therefore, encouraging more women to pursue STEM degrees does not necessarily mean that they will pursue careers in STEM after graduation. Second, the results indicate substantial gender differences in returns within STEM employment, which may be consistent with implicit gender discrimination and challenge the ability of higher education to promote gender equality in pay. High-achieving men with STEM majors receive greater wage returns to their academic achievement than high-achieving women when employed in STEM. While non-STEM majors in non-STEM jobs do not experience a statistically significant gender wage gap one year after graduation, STEM majors employed in STEM jobs face an 18 per cent gap, almost half of which remains unexplained by observed differences in educational and job characteristics. When employed in high-paying occupations and industries, women receive lower wage returns than men and experience lower returns to academic achievement and ability, suggesting that technical education alone is insufficient to achieve pay parity.

Finally, this is the first study to explore the contribution of combining study and work to the subsequent career paths of graduates in the context of STEM. Having a STEM job during the senior year at university is one of the strongest predictors of post-graduation STEM employment for both STEM and non-STEM majors. This finding highlights the importance of labour market experience for early career development and suggests that higher education policy alone may have limited capacity to reduce labour market inequality.

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Information about the authors

- Ksenia Rozhkova – Ph.D. (economics), senior researcher, Laboratory for Labour Market Studies, HSE university, Moscow, Russia. Email: krozhkova@hse.ru
- Sergey Roshchin – Ph.D. (economics), Head of Laboratory for Labour Market Studies, HSE university, Moscow, Russia. Email: sroshchin@hse.ru
- Natalya Yemelina – Ph.D. (economics), senior researcher, Laboratory for Labour Market Studies, HSE university, Moscow, Russia. Email: nyemelina@hse.ru

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Supplementary material 1

Tables

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