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# The evolution of educational wage differentials for women and men in Germany, from 1996 to 2019

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## Abstract

This paper studies the evolution of three higher education wage differentials from 1996 to 2019 in Germany. We distinguish between degrees from academic universities, degrees from universities of applied sciences, and the master craftsman/craftswoman certificate. The educational reference category is a standard degree within the German vocational education and training system. Based on samples of male and female workers from the Socio-Economic Panel Study (SOEP), regression methods show that all three educational wage differentials in 2019 exceeded the ones in 1996. However, workers graduating from universities experienced an inverse u-shape pattern with a maximum of about 0.5 log points around 2012. Since then, their wage differential decreased by nearly ten percent (about 0.045 log points). Although the decrease is not statistically significant at conventional levels, we think that nearly ten percent can be regarded as economically meaningful. We argue that this pattern is related to university expansion and changes in graduates' subject-choice composition during that expansion. The paper concludes with a discussion of possible alternative explanations.

**Keywords:** Educational Wage Differentials, Gender Gaps, Higher Education, Returns to Education

**JEL Classification:** J31, J16, I23, I26

## 1 Introduction

The expansion of university education fostered a dynamic change in the workforce's educational composition, and which has received attention from policymakers and researchers (e.g., Authoring Group NRoE 2018; Araki 2020; Goldin and Katz 2008; Horowitz 2018). The debate revolves around whether the increase of highly educated individuals may, presumably with some lag, lead to stronger competition among university graduates and put pressure on their relative wages. Alternatively, highly educated individuals may experience even larger wage differentials (and vice versa for low-skilled individuals). The increase in university-educated individuals

may foster innovation and trade, boosting investment into new capital-intensive automation technologies like artificial intelligence. This paper studies whether relative wages of high-skilled individuals increased or decreased during the recent expansion of university education in Germany.

The literature often focuses on two educational categories, college graduates and others, while the resulting wage differential is referred to as the skill (or college wage) premium. According to Goldin and Katz (2008), the skill premium in the United States increased from 1980 to 2005, which they explain as resulting from a technology-driven growth in the demand for college graduates and non-routine tasks (see also Lindley and Machin 2016, among others). More recent evidence suggests a stagnating skill premium in the US after 2010 (Valletta 2018) and a moderate decrease in college wage premium in European countries between 2005 and 2015 (Green

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and Henseke 2021). Reinhold and Thomsen (2017) study the development of daily wages from a cohort of young employees based on administrative data in Germany until 2010. Differentiating between three skills categories, they find that high-skilled employees, compared to middle and low-skilled employees, experienced a rising skill premium.

The German higher education system presumably is more differentiated than the Anglo-Saxon one. Taking the perspective of *one* higher education premium ignores the fact that there are at least *three specific and well-defined higher educational degree categories* in Germany (Authoring Group NRoE 2018): Degrees from academic universities (referred to as universities, U, in what follows), degrees from universities of applied sciences (UAS), and the master craftsman/craftswoman certificate (MC). MC is the highest post-secondary degree outside the university system in Germany. It builds on a fourth qualification-type obtained via the dual vocational apprenticeship system (named vocational education and training, VET). These degrees vary significantly in academic content and length of study (see Sect. 2). Our study contributes to the international literature in a novel way by looking at the evolution of these three higher educational (gross) wage differentials compared to a VET degree using data from the Socio-Economic Panel Study (SOEP) from 1996 to 2019. In addition, we consider the major studied while at a university of applied sciences or university to highlight recent changes in the student composition of these majors and their potential relation to educational wage differentials.

Similar to the literature, we find that in Germany, in the period from 1996 to 2019, educational wage differentials increased despite the higher education expansion and the higher educated workforce participation rates. We further this field of literature by demonstrating specific evolutionary patterns for each educational degree—a pattern that evolves differently for women and men. While all three educational wage differentials increased compared to a VET degree, workers graduating from universities experienced a halt starting around 2012, when it reached its highest level so far (about 0.5 log points) and afterward a decrease of about 0.045 log points. Although the decrease is not statistically significant at the conventional level of 95%, we think it is economically meaningful. We argue that this pattern is related to the expansion of university education. Furthermore, relatively more students graduated in arts and social sciences, subjects for which wage differentials are lower than for other majors.

The article proceeds as follows. Sect. 2 introduces the chosen educational categories and highlights the expansion of university education. Sect. 3 describes the data, its operationalization, and our research approach. Sect. 4

discusses the new empirical findings on the evolution of educational wage differentials. Sect. 5 discusses changes in the subject composition of study choices among graduates and the evolution of wage differentials. Finally, Sect. 6 concludes with a discussion on further factors that may have contributed to our main findings.

## 2 The evolution of the educational composition of the population, aged 30 to 55

### 2.1 Education and wages

Economic reasoning suggests that when young adults invest in higher education, they compare costs and returns over the life cycle and consider their own educational and occupational preferences (e.g., Backes-Gellner et al. 2021; Flossmann and Pohlmeier 2006; Pfeiffer and Stichnoth 2015; Westphal et al. 2022). Wage differentials emerge in order to compensate for these investments (for other reasons for wage differentials, such as amenities, skills, effort, risk, or social interactions, see e.g., Anger and Heineck 2010; Gebel and Heineck 2019; Krueger and Schkade 2008). *Educational wage differentials* signal investment opportunities and differences in the effort needed to acquire specific degrees. In a thought experiment where wage differentials would be zero, the economic incentives for educational investments would be low or absent.

Since wages and educational wage differentials result from several economy-wide and individual-specific factors, identifying specific factors strong enough to change their trajectory can be challenging. The part of the wage attributed to the level of education depends on the competencies attained in formal educational institutions. In addition, individuals select themselves into these institutions depending on their perceived abilities and socio-economic background (e.g., Becker and Hecken 2008; Hillmert and Jacob 2003; Müller and Pollak 2007), highlighting the role of preferences for academic education (see Kamhöfer et al. 2019) as well as otherwise often unobserved barriers to and benefits from educational pathways.

The overall amount of educational investment in society, or the wage levels for a given competence profile are driven by factors that the investing individual, as a rule, cannot control. Thus, *educational wage differentials* depend on the amount and quality of educational investments, on competencies that are not certified or are hard to certify, and on factors that determine the overall supply of and demand for these competencies in the economy.

### 2.2 Educational categories used in the study

The German education system has traditionally been stratified and separated between occupational and

academic pillars (Authoring Group NRoE 2018; Baethge 2007). There are two types of academic educational institutions available: universities and universities of applied sciences. Both types of institutions vary in their academic orientation and the subjects offered. *Universities of applied sciences* focus on a practically relevant set of qualifications predominantly in economics (as a rule, business economics), social work, and engineering. They often have strong ties to the local economy. *Universities* are broader in their portfolio and offer subjects encompassing the entire academic spectrum from the arts, economics and business economics, social and natural sciences, and sports to law, medicine, and veterinary medicine.

In Germany, matriculation at universities of applied sciences and universities requires an entrance qualification, which demands successful graduation from upper secondary schooling (typically after 12 or 13 years of overall schooling).<sup>1</sup> Since 2009, both offer two degrees, bachelor's and master's degree, gradually replacing traditional degrees such as the "Diplom". In addition, universities offer the "Staatsexamen" for teaching, medicine, and law, which is, by and large, comparable to a master's degree. A bachelor's degree requires an investment of at least three years and a master's degree of at least two additional years. In addition to choosing the type of degree and higher education institution, students can also choose between a wealth of different subjects (from among more than 17,000 different courses, Authoring Group NRoE 2018).

There is a third avenue to achieving a tertiary educational qualification in Germany: The MC certificate is part of the vocational pillar, the central qualification system besides the academic pillar. It is specific to a craft such as a hairstylist or mechatronic technician and is less academic in its learning contents. It enables certificate holders to open their own firms in their respective craft and opens up supervising positions for them. An MC certificate builds on the already acquired qualification of a VET degree, which typically lasts 3 to 4 years. The

acquisition of the MC certificate then lasts an additional 2 to 3 years.

### 2.3 Dynamic upskilling in the population aged 30 to 55

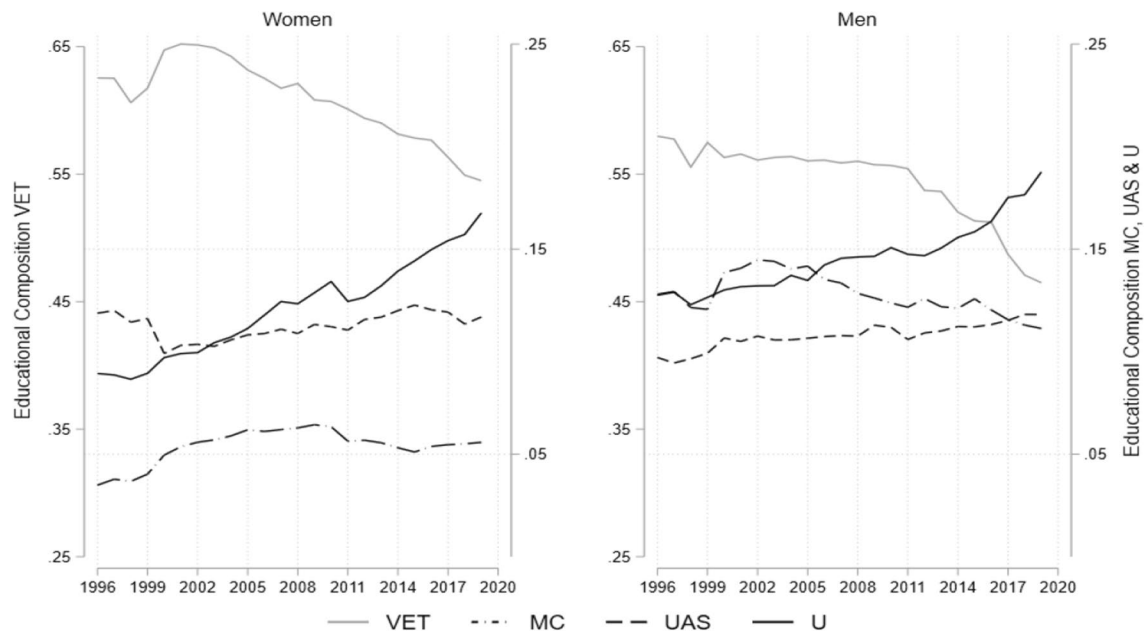
Germany experienced a significant expansion in university education in the new millennium, which changed the educational composition of the German population (e.g., Authoring Group NRoE 2018). Figure 1 illustrates the evolution of the educational composition in the population aged 30 to 55, separately for women and men, based on samples taken from SOEP.

Note that the scales used for VET (left side) and the three higher educational degrees (right side) differ. Over the 24 years considered here, highly educated young people steadily entered the observed age group whereas older and less educated people left it. As a result, the share of individuals with a U (UAS) degree increased from 10.8 (10.8) percent in 1996 to 17.8 (11.9) percent in 2019. The share of individuals with a VET degree decreased from 60.0 percent in 1996 to 50.5 percent in 2019. Upskilling among women is a driver of the change in the educational composition from 1996 to 2019. The share of women with a U degree increased by 7.8% points and that of men by 6.0% points. In this period, the share of women with UAS degrees remained approximately the same (−0.0% points) while the share of men increased by 2.1% points. Summing up, in 2019, approximately 28.0 percent of women and 30.6 percent of men in the 30 to 55 age bracket held either a UAS or a U degree, compared to 20.8 percent for women and 22.5 percent for men in 1996. More women (from 3.5 to 5.6 percent) and fewer men (from 12.8 to 11.1 percent) with an MC certificate entered this age bracket.

## 3 The empirical approach for assessing educational wage differentials

**Data.** Our empirical analyses of the evolution of wage differentials are based on samples from the German SOEP (Goebel et al. 2019; SOEP-Core 2021). The SOEP is a representative longitudinal panel study of German households. It concentrates on multiple topics ranging from employment, well-being, health, working hours, and earnings to daily life. The study began in 1984 and currently includes 36 waves. We use individual-level data spanning 24 years from the years 1996 to 2019. Our estimation sample is unbalanced and restricted to 259,555 observations of 35,890 employed individuals, 18,455 of whom are women. The samples include employees and the self-employed. Although the wage determining processes may differ between the two groups, economic arguments suggest that they are related. While the self-employed have to generate their wages from residual profits, employees receive a fixed wage bargained *ex-ante*

<sup>1</sup> Higher education has gradually opened to individuals with vocational training and work experience or an MC certificate who do not otherwise possess a higher education entry qualification. The overall share of these students remains below four percent of all students, and less than two percent of all alumni (Brändle and Ordemann 2020). We do not investigate the pathways into higher education or this subpopulation. According to Ordemann (2019) they have similar monetary but slightly lower non-monetary labour market returns than other alumni. Arguably, the content of the educational degrees may have differed at the beginning of the observation period from those common in (West) Germany, and this may have influenced the evolution of educational wage differentials. In our previous version of this paper (Ordemann and Pfeiffer 2021), we also performed the analysis separately for East and West Germany.



**Fig. 1** The educational composition in the population 1996–2019 (Women/Men; in %). Note: Individuals aged 30 to 55. The notation reads as follows: *VET* vocational education and training, *MC* master craftsmen/craftswomen, *UAS* university of applied sciences, and *U* university. The shares of the four educational categories do not reach 100% because the fifth category, no degree, is excluded in this figure. Their average shares (total) are 11.8% for 1996 and 13.1% for 2019. Source: SOEP v36, authors' own calculations

(e.g., Pfeiffer and Pohlmeier 1992). If a risk-adjusted wage in self-employment differs from an employee's wage, workers can become employees and vice versa.

We concentrate on female and male prime-age workers aged 30 to 55. In this age group, as a rule, individuals are members of the workforce, although participation rates are still higher for the better educated. A difference that is higher among women compared to men. In our SOEP samples, the share of working women increased from 67.6% in 1996 to 85.5% in 2019 and from 91.2 to 92.6% among men. More investment in education increases the opportunity cost of not working. Therefore, individuals with a higher educational degree tend to show higher participation rates compared to VET (for women in Germany, also compare Westphal et al. 2022). However, the employment participation rates also increased for women with a VET degree and women with no degree. While the participation rates of women increased, men still display higher participation rates. Participation rates among men exceeded the ones for women by 7.1 points in 2019, compared to 23.6 in 1996, which is a result in part of the upskilling among women (for more details, see Ordemann and Pfeiffer 2021). Nevertheless, we think concentrating on the age group of 30 to 55 year old workers could be helpful in lowering potential estimation biases associated with the endogeneity of labour market

entries into and exits from young adulthood and retirement respectively.

The investigation starts in 1996 for two reasons. The first reason is that, according to Gebel and Pfeiffer (2010), 1996 was the year in which estimates of the returns to education reached their minimum value in the period 1984 to 2006 in West Germany. The period of strong educational expansion after World War II exerted downward pressure on wages for skilled workers, and the estimated returns to education were (moderately) decreasing from 1984 onward. However, after 1996 estimated returns to education started to increase once again.

The second reason is that German reunification in 1990 may have influenced the German wage structure, especially during the years immediately following reunification (e.g., Gernandt and Pfeiffer 2007, 2009). Thus by 1996, 6 years after reunification, a relevant part of the specific impact of reunification on the educational wage differentials should already have taken place.

**Variables.** The dependent variable of our analyses is the natural logarithm of gross earnings per hours worked. It is obtained separately for each year by the trimmed real gross monthly income reported in the previous month. The reported income is divided by the factor of 4.33 times the trimmed actual working hours at the end of the sample selection. In addition, the obtained wage was



trimmed before transforming it into the natural logarithm. The trimming of all variables is performed on the one percent level; all incomes are depreciated to 2015. Additional payments, such as holiday pay are excluded.

The explanatory variable in focus is the highest educational degree. We use degrees provided by the SOEP, which reflect the unique characteristics of the German education system: no (post-secondary) degree (or not yet completed), apprenticeship or vocational training, master craftsmanship, and university (of applied sciences).

Some adjustments to the variables provided by the SOEP are made. First, we add cooperative education and civil servant training to the category of master craftsmanship. Cooperative education combines vocational training with academic study but is still bound to the firm with which students have a work contract, who shape the curricula of the cooperative education institution. Second, higher education degrees obtained in a foreign country were added to the category of universities of applied sciences to reflect the diversity of higher education from all over the world in this educational category.

We focus on these three higher education categories, although each of them may have further heterogeneities.<sup>2</sup> While it will not be possible with the SOEP data to analyse the variety of study subjects described in Sect. 2.2, we will group and examine seven majors: arts, law, economics, social sciences, medicine, natural sciences, and engineering.

We control for the individual potential work experience subdivided into percentiles, sex, migration background, partner, employment of the partner, children in the household, city vs. country living, West vs. East Germany, and for the sample the respondent initially belonged to. Additional file 1: Table S1 in the contains descriptive statistics of all variables.

*Method.* We start with the *average wage differences* of the three higher educational degrees compared to a VET degree. Subsequently, we estimate *adjusted educational wage differentials*. Based on OLS wage regression

models, we report the partial coefficients for the highest educational degrees for each year from 1996 to 2019.<sup>3</sup> VET is used as the reference group in our analyses. These partial coefficients may not indicate the causal economic effect of the educational investments needed to gain the respective educational degree.

Estimates of educational wage differences and differentials over 24 years may exhibit, to some degree, erratic patterns from year to year. There is no explicit theory supporting the notion that educational wage differences and differentials should not display such a pattern. Nevertheless, we cannot exclude the possibility that part of this pattern found in our analyses is the result of the various samples retrieved over such a long time period. For instance, the number of observations in our estimation samples varied from 3681 to 7990. To get rid of such types of randomness to some degree for our subsequent analyses, we use Epanechnikov kernel-weighted local-mean polynomial smoothing for the figures produced from the estimates.

## 4 The evolution of educational wage differences and differentials, 1996 to 2019

### 4.1 The evolution of educational wage differences

In the years under investigation, 1996 to 2019, the average real wages in our samples doubled (Additional file 1: Table S2). On average, they grew annually by 3.33% among women and 3.32% among men (Additional file 1: Table S3). This significant growth is, at least to some extent, the result of the stable performance of the German economy (e.g., Burda and Seele 2017, 2020; Dustmann et al. 2014). The wage growth rates vary between the educational categories. Workers with a degree from UAS experienced above average growth rates (especially women, at 3.92%, and to a lesser extent men, at 3.53%), and workers with no degree below average growth rates (2.78% for women, 2.47% for men). Women with an MC certificate experienced below average growth rates (3.17%), men above (3.51%). Women with a U degree experienced below average growth rates while men with a U degree experience an average growth rate. Despite the significant decrease in the share of workers with a VET degree, their wages also grew below the average (women: 3.05%, and men 3.07%).

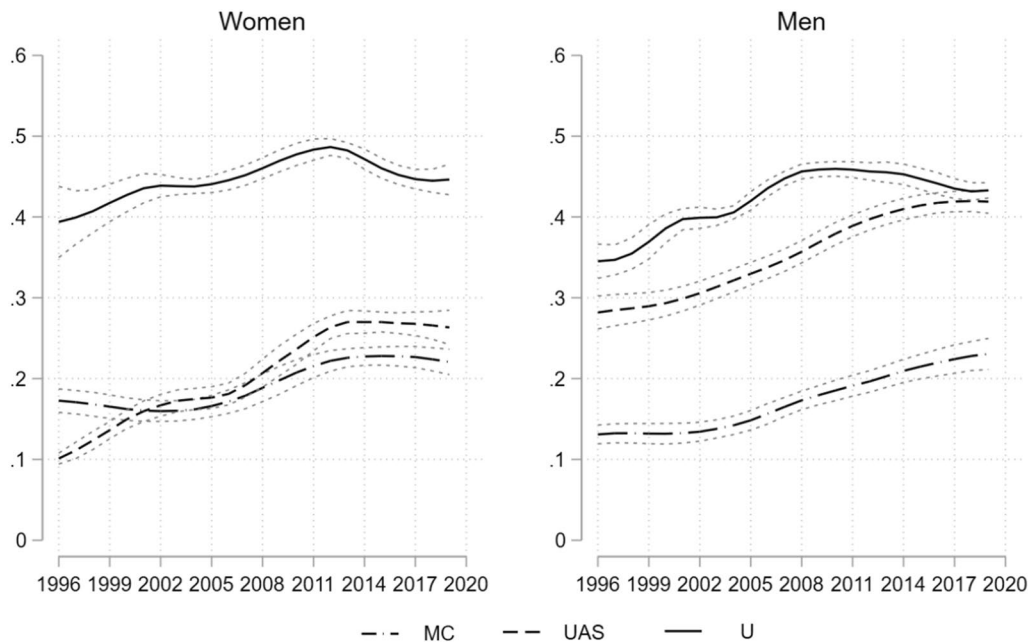
The growth rates vary between the age groups of younger (30 to 39 years old) and older (40 to 55 years old) workers (Additional file 1: Table S3). They are, on average, higher for the samples of younger women with a tertiary degree compared to the samples of older

<sup>2</sup> For reasons of robustness, we performed additional regressions which include three additional dummy variables, one for cooperative education, one for civil servant training, and one for higher education degrees obtained in a foreign country, and found no differences for the adjusted U differentials. There are some moderate differences for UAS and MC which are discussed in Sect. 4.2 below.

<sup>3</sup> Further estimates were calculated separately for younger (30–39) and older workers (40–55), based on samples of workers aged 25 to 65, and separately for workers from Eastern and Western Germany. Additional checks restricted the sample to employees only, without the self-employed. Furthermore, we estimated the wage differentials separating VET graduates into those who attained an *Abitur* as formal entrance certification into higher education and those who had a lower secondary degree. The regression tables for these additional findings as well as the number of observa-

Footnote 3 (continued)

tions for each year and the adjusted  $R^2$  of our main analyses are available in Ordemann and Pfeiffer (2021).



**Fig. 2** Smoothed educational wage differences, 1996 to 2019 (Women/Men; in ln, 95%- CI). Note: Employed individuals aged 30 to 55. The notation reads as follows: VET vocational education and training, MC master craftsmen/craftswomen, UAS university of applied sciences, and U university. Differences in the ln of real wages compared to VET. The average mean differences of no degree to VET for men are  $-0.13$  and for women  $-0.17$ . The average real wages can be found in Additional file 1: Table S2. Source: SOEP v36, authors' own calculations

women with the same degree, which reflects the process of upskilling among young women in particular. Among men, younger workers experienced moderately lower wage growth, except for those with a VET and MC degree. Here, younger men experience a stronger wage growth than older men.

Figure 2 displays the smoothed average differences of the natural logarithm of the educational wage of the three highest educational degrees relative to the VET degree from 1996 to 2019. All three categories of higher education show an upward trend in wage differences compared to the VET degree. Women (on the left side) with a U degree have higher wage differences compared to men (right side), although the gap narrows toward the end of the observation period. In 2019, the average wage differentials are 0.45 log points for women and 0.42 log points for men. For UAS, the differences among women are significantly lower compared to the ones among men. In addition, the differences for a UAS degree are more similar to those of an MC degree for women and more similar to a U degree for men.

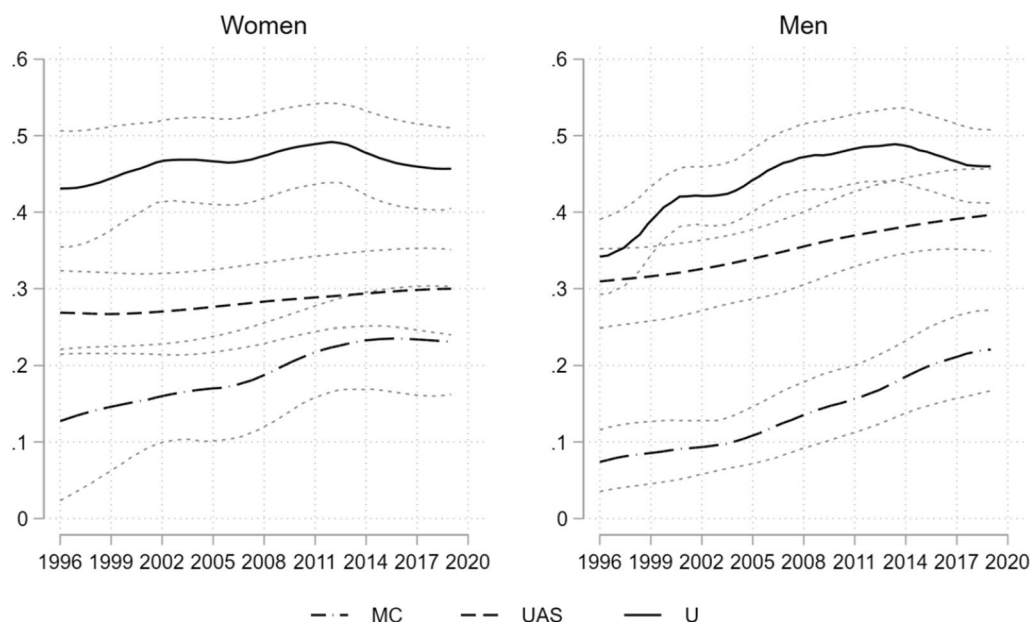
The three educational wage differences among women increase until 2012 and then stagnate (MC, UAS) or decline (U). Among men, the pattern differs slightly. The average wage differences increased steadily for MC and UAS after 2000. Growth slows down after 2014. However, for male workers graduating from U, the differences

increase only until 2008, and decline from 2014 onward. As a result, average wage differences for U and UAS converge towards the end of the observation period in 2019.

#### 4.2 The evolution of educational wage differentials

The evolution of the adjusted three higher *educational wage differentials* for U and UAS degrees, as well as for MC in comparison to a VET qualification is shown in Fig. 3 for the period 1996 to 2019. The adjusted educational wage differentials display, by and large, a similar evolutionary pattern as the educational wage differences in Fig. 2 above. However, the adjusted wage differentials for men with a U degree are slightly higher than the mean wage differences. The adjusted wage differentials for women and men workers with a U degree are decreasing after 2012. The decrease amounts to about 0.045 log points. Although the decrease is not statistically significant, given the overlapping confidence intervals, it is economically meaningful. Compared to the highest estimated wage differentials for U workers so far, which was about 0.5 log points around 2012, it is nearly ten percent lower in 2019.

The adjusted wage differentials were higher for women at the beginning of the observation period while they are of a similar magnitude among both men and women at the end. The convergence of the adjusted educational wage differentials for the group of female and male



**Fig. 3** Adjusted smoothed educational wage differentials, 1996 to 2019 (Women/Men; in ln, 95% CI). Note: Employed individuals, aged 30 to 55. The notation reads as follows: *VET* vocational education and training, *MC* master craftsmen/craftswomen, *UAS* university of applied sciences, and *U* university. OLS estimates with ln real wages (educational reference category: *VET*). Individuals without any degree earn significantly less (for women on average, 19.6%, for men 11.8% without a clear time trend). The wage differentials, including 95% CI based on robust errors, can be found in Additional file 1: Table S4. Source: SOEP v36, authors' own calculations

workers with a U degree may have several causes. One cause, presumably, is the significant expansion of university education among women after 2000. Given an increasing number of highly educated women entering employment, it may have been no longer necessary for firms to increase monetary incentives for the employment participation of women compared to men. Such an explanation assumes that women and men with a U degree compete in comparable economic segments and are substitutes at this aggregate level. There is some evidence to support this idea from Francesconi and Parey (2018), who find that there is no gender wage gap at the beginning of the career. A second cause may result from a change in the composition of subject choice as subjects differ in their content, prestige, and expected wages. We further investigate this potential cause in more detail in the next section.

In addition, Fig. 3 indicates a stronger increase for UAS and MC compared to U throughout the observation period for men. Thus the wage differentials between U and UAS, which were relatively high and significantly different around 2012 converge towards the end of the observation period. While on average the adjusted differential for U is still higher compared to UAS, the confidence intervals overlap in 2019.

The adjusted wage differentials for men with a UAS degree are always significantly higher compared to MC.

Since the increase of the wage differentials of MC outperforms those of UAS, the difference between the two is lower in 2019 compared to 1996. For workers with a UAS degree, the estimated wage differentials are higher for men compared to women. For workers with an MC certificate, the estimated wage differentials are higher for women compared to men. Among women, the wage differentials between UAS and MC workers do not statistically differ in the observation period. However, the estimated coefficients are always higher for UAS compared to MC.

As a robustness check, we performed additional regressions in which a degree from cooperative education, civil servant training, and a higher education degree obtained in a foreign country were added in the form of dummy variables in the estimation equation instead of including them in the categories of the MC or UAS degrees. The comparison reveals that there are virtually no differences in the estimated coefficients for the adjusted U differential. In contrast, the UAS differentials are, on average, 0.01 log points higher over all 24 coefficients for both women and men. The adjusted wage differentials for MC, averaged over all 24 estimates, turned out to be 0.02 log points lower for women and 0.01 log points higher for men. These later findings are interesting on their own and may even deserve additional research to better capture the diversity of higher education degrees in Germany.

**Table 1** Share of first degrees in study majors from UAS and U, 1993 and 2011 (in %).

Type	UAS				U			
	Women		Men		Women		Men	
Year	1993	2011	1993	2011	1993	2011	1993	2011
Arts	–	–	–	–	20.7	26.5	7.6	11.7
Law	–	–	–	–	7.6	4.4	7.5	4.6
Economics	40.9	41.5	25.3	27.6	11.3	11.0	15.1	15.9
Social Sc	21.5	24.5	4.1	5.5	15.3	21.8	5.9	12.5
Medicine	–	–	–	–	12.0	6.6	11.9	5.2
Natural Sc	–	–	–	–	15.9	15.5	16.8	18.6
Engineering	20.5	19.1	64.1	58.6	6.4	6.1	28.4	27.0

The notation reads as follows: *UAS* university of applied sciences, *U* university, *Sc* sciences. The numbers in columns do not add to 100 percent because not all majors have been included; teachers are included in the group of social sciences

Source: DZHW ICE (Federal Statistical Office, Main Reports, 3301); authors' own calculations

However, they are quantitatively not significant enough to modify our main findings and conclusions.

## 5 Changes in the composition of subjects studied and educational wage differentials

The returns to university education are heterogeneous and empirically vary between subjects (e.g., Francesconi and Parey 2018; Klein 2016). Table 1 groups the distribution of subjects in the seven most prominent academic majors (arts, law, economics, social sciences, medicine, natural science, and engineering) separately for women and men and for U and UAS, and comparing 1993 and 2011. There appear to be some relevant changes over time. For all graduates, there is an increase of 12.3% points in the share of arts and social sciences among women and of 10.7% points among men. In comparison, the share of students graduating in law and medicine, both high-wage subjects, decreased. The share for natural sciences, engineering, and economics remained almost constant.

To assess the possible role these changes may exert on educational wage differentials, our analysis proceeds in two steps: We examine the subject-specific wage differentials before we turn to the strength of their relationship with the expansion of study majors. Table 2 presents the adjusted educational wage differentials by major for females (part a) and males (part b). Graduates in medicine, law, economics, engineering, and natural sciences experience higher wage differentials relative to employees with a VET degree, and compared to arts and social sciences graduates. A straightforward calculation reveals an average difference of around 0.18 log points in 2012 for women and 0.28 log points for men between the two poles of wage differentials.

The findings also reveal that U graduates earn higher wages compared to UAS graduates in general and in particular when they studied the same major. For example, the adjusted wage differential for economists with a U degree was 0.60 (0.49) for women (men) in 2012 and 0.43 (0.42) for women (men) with a UAS degree. According to our interpretation, this difference mirrors the higher investment costs since time-to-graduation at a university lasts 5 to 6 years, on average; In contrast, it lasts 3 to 4 years at a university of applied sciences (Authoring Group NRoE 2020).

The adjusted subject-specific wage differentials are relatively stable over time, especially among engineering and law. However, the wage differentials for arts, social and also for natural sciences decreased, although not without variations among women and men. For instance, the wage differentials among women graduating at U decreased from 0.42 in 2012 to 0.36 in 2019 for arts (minus 0.06 log points) and from 0.46 to 0.36 for social sciences (minus 0.10 log points). Since the share of arts and social sciences increased by 12.3% points among women and 10.7 among men between 1993 and 2011 (Table 1), the decrease in these adjusted wage differentials presumably contributed to the stagnation of the overall U adjusted wage differential.

The graduation growth rates are interpreted as proxies for the expansionary effect that the increasing number of graduates may have had on wages (see Additional file 1: Table S5 in the Online Appendix). We analyse the period between 2002 and 2008, when the significant expansion in first degree attainment took place (Ordemann and Pfeiffer 2021). As universities offer the most encompassing subject portfolio, we concentrate on the changes for university graduates. During this period the graduation growth rates vary between 0.97 among



**Table 2** Educational wage differentials by study majors, four selected years (in ln)

(a) Women	2012		2014		2016		2019	
	UAS	U	UAS	U	UAS	U	UAS	U
Arts	–	0.42***	–	0.35***	–	0.31***	–	0.36***
Law	–	0.59***	–	0.56***	–	0.58***	–	0.57***
Economics	0.43***	0.60***	0.41***	0.59***	0.42***	0.61***	0.38***	0.53***
Social Sc	0.27***	0.46***	0.34***	0.34***	0.25***	0.32***	0.21***	0.36***
Medicine	–	0.83***	–	0.82***	–	0.78***	–	0.96***
Natural Sc	–	0.62***	–	0.59***	–	0.47***	–	0.52***
Engineering	0.39***	0.48***	0.34***	0.46***	0.32***	0.44***	0.31***	0.53***
# obs./R <sup>2</sup>	2,900	0.22	2,409	0.23	2,045	0.22	1,990	0.23
(b) Men	2012		2014		2016		2019	
	UAS	U	UAS	U	UAS	U	UAS	U
Arts	–	0.24***	–	0.33***	–	0.19 <sup>a</sup>	–	0.26***
Law	–	0.64***	–	0.68***	–	0.66***	–	0.74***
Economics	0.42***	0.49***	0.35***	0.41***	0.39***	0.42***	0.41***	0.52***
Social Sc	0.21***	0.37***	0.07ns <sup>a</sup>	0.34***	0.28 <sup>***a</sup>	0.34***	0.10	0.35***
Medicine	–	0.71***	–	0.71***	–	0.78***	–	0.71 <sup>***a</sup>
Natural Sc	–	0.56***	–	0.57***	–	0.55***	–	0.48***
Engineering	0.48***	0.54***	0.48***	0.55***	0.46***	0.50***	0.51***	0.58***
# obs./R <sup>2</sup>	2,877	0.32	2,383	0.32	1,960	0.30	1,883	0.33

Employed individuals aged 30 to 55. The notation reads as follows: *UAS* university of applied sciences, *U* university, *Sc* sciences. OLS estimates with ln real wages (educational reference category: VET). Statistical significance level of the estimates: \* for  $p < .05$ , \*\* for  $p < 0.01$ , and \*\*\* for  $p < .001$ . Findings for other subjects, such as agricultural studies and fine arts are not included in the table. <sup>a</sup>The estimated coefficient for the subject in the year was implausible. We therefore report the coefficient from the previous/following year's estimates

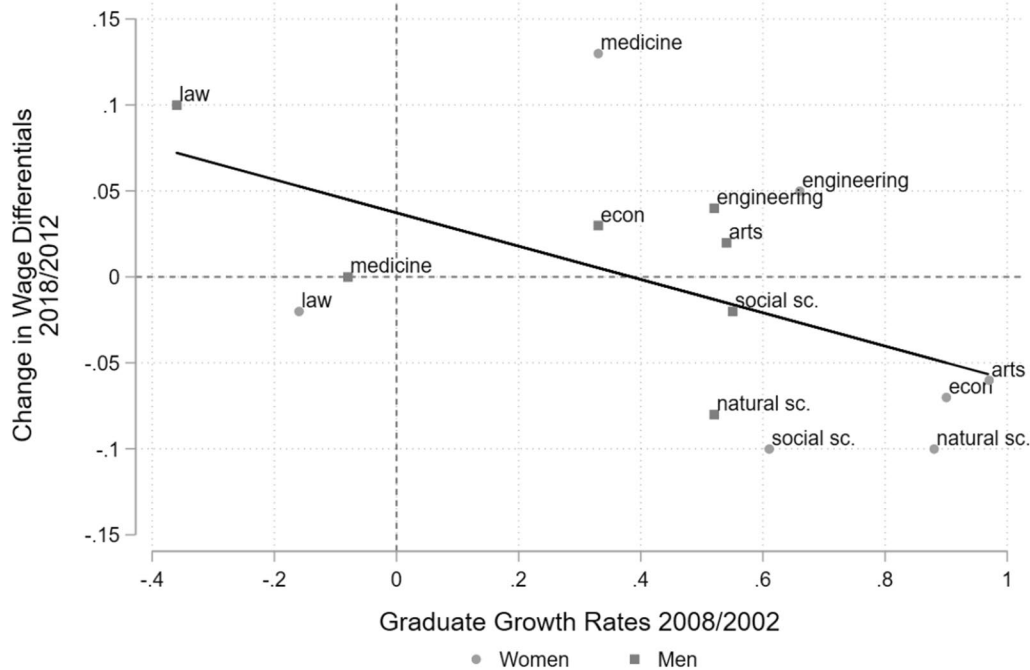
Source: SOEP v36; authors' own calculations

women for arts and  $-0.36$  among men for law. We expect a delayed effect of the expansion on the labour market. Therefore, we investigate how the wage differentials changed between 2012 and 2019. The growth rates in subject-specific wage differentials range for women from  $-0.10$  for the social sciences to  $0.13$  for medicine, and for men from  $-0.08$  in natural sciences to  $0.10$  in law (see Additional file 1: Table S5).

For instance, the graduate growth rate in arts studied at university was  $0.97$  for women, and  $0.54$  for men, whereas the growth in wage differentials was  $-0.06$  for women and  $0.02$  for men. Similarly, the graduate growth rate in economics studied at university was  $0.90$  for women, and  $0.33$  for men, whereas the growth in wage differentials was  $-0.07$  for women and  $0.03$  for men. Majors that expanded most in terms of graduates between 2002 and 2008 are also, on average, subject to the strongest decreases in wage differentials. However, there are two that act as outliers in this relationship: engineering and medicine retained higher wage differentials among women compared to men, although the growth

rates of women graduates have been higher compared to those of men.

Figure 4 summarises the resulting strength of the relationship between the expansion in study majors (graduate growth rates) and subject-specific educational wage differentials. Overall, the figure suggests that there is a negative relationship between the two growth rates for university graduates. On average, a ten percent increase in graduates from a specific subject is associated with a roughly  $0.01$  log point reduction in the adjusted subject-specific wage differential relative to VET. This relationship should not be interpreted as a “law”. It is not irrespective of time, subject choice, and economic conditions. The relationship illustrated in the figure depends on the specific conditions and socio-economic circumstances at the time when the educational expansion started, i.e., the existing stock of graduates, the strength of the expansion, the rate of retirement among lower-skilled workers, as well as the economic circumstances when the graduates begin their careers (e.g., Goldin and Katz 2008).



**Fig. 4** The change of subject-specific wage differentials and graduate growth rates. Note: The notation reads as follows: sc sciences. Illustration based on findings presented in Additional file 1: Table S5.

## 6 Summary and open questions

This study investigates the evolution of *educational wage differentials* for three categories of higher education compared to a VET degree in Germany during the period of expansion of university education. It has been documented that in the German context, the three categories of tertiary education matter for the evolution of wage differentials. OLS findings demonstrate that the adjusted wage differentials for university graduates increased until around 2012 to about 0.5 log points before they stagnate for some years and decline after 2015. In 2019, the wage differential is assessed as being about 0.045 log point lower compared to 2012, which nearly amounts to a ten percent decrease.

The adjusted wage differentials for men with a U and a UAS degree converged. The adjusted wage differentials for men with a UAS degree increased during the observation period as well, although the speed of the increase slowed down after 2015. The adjusted wage differentials for men with an MC qualification increased steadily, although they always remain significantly lower compared to UAS. Among women, the wage differentials for U are significantly higher compared to UAS throughout the observation period, while the wage differentials for UAS increase only slightly, and for MC stagnate towards the end of the observation period. The study documents an above average growth in graduates of lower average

wage majors such as the arts and social sciences during the university expansion post-2000. According to our interpretation, there is some initial evidence that the halt in the increase of the adjusted U wage differentials, the expansion of university education and the changes in the composition of majors studied during this expansion are related—a conclusion that is underlined by international evidence regarding the importance of subject choice for wage differentials (e.g., Machin and Puhani 2003; Michelmore and Sassler 2016).

A number of open questions remain. After 2012, the Bologna Process, with its introduction of first- and second-cycle degrees may have influenced the evolution of the adjusted educational wage differentials. If the share of workers with a bachelor's degree from a university in our samples is increasing this may also have contributed to the stagnation of the adjusted U wage differentials. Due to data restrictions, we are not able to assess this possibility. In our estimation samples, the case numbers of workers with a UAS bachelor's degree doubled between 2014 and 2019 (from 56 to 110). Since these workers have lower wage differentials compared to workers with a Diploma or a master's degree, this development may have contributed to the stagnation of the increase in UAS adjusted wage differentials after 2015. However, most bachelor graduates from universities seem to go on to

attain a master's degree (Authoring Group NRoE 2018). In our samples, there are no workers with a U Bachelor's degree.

In the last few decades, more students with a lower preference for education at a university may have entered universities and this type of self-selection may have, in turn, contributed to the stagnation of U wage differentials (e.g., Carneiro and Lee 2011; Kroher et al. 2021; Ordemann 2021). However, the incentive to enter university may also have been fostered by expectations about a higher future demand for graduates driven by technological change. According to Dauth et al. (2021), continued automation in Germany positively affected incumbent high-skilled workers, decreased the demand for workers with vocational education and increased the incentives for talented young adults to enter university instead of vocational education. Since we have neither information on university preference parameters nor expectations about future labour market prospects, it is left for further research to look deeper into these types of explanation.

Another hypothesis posits that the composition of workers with a VET qualification may have changed with respect to formal secondary education between 1996 and 2019. While more school leavers graduated with the formal certificate ("Abitur") needed to enter higher education, the wish to attain a similar position to their parents may have diverted many of them into VET (Konietzka and Hensel 2017). In this process, the human capital of workers with a VET qualification may have increased over time, contributing to the stagnation of the wage differentials compared to U workers. Indeed, further regression analysis confirmed that VET workers with an *Abitur* earned significantly higher wages than those with a VET qualification but without an *Abitur* in almost all years. However, this estimated wage premium decreased in the years 2015/19 compared to the years 2008/12 according to our regressions, for women from 0.174 to 0.142 and for men from 0.211 to 0.162. This finding does not seem to support the change-in-VET-hypothesis, although it is not a formal falsification. Future research on the relevance of these considerations and the influence of possible other changes to the contents of VET could be helpful.

Ordemann and Pfeiffer (2021) analysed the gender specific participation rates and working hours, based on the same samples from the SOEP used in the present study. They report increasing participation rates between 1996 and 2019. Women's participation rates were still lower than men's in 2019, although the gap narrowed. Quite surprisingly, despite upskilling, the average hours worked in the samples of workers aged 30 to 55 decreased from 39.4 h in 1996 to 37.1 h in 2019. According to Bick et al. (2019), working hours and wages display an inverted

u-shape pattern, such that wages decline when working hours per week exceed specific benchmarks such as the average working hours. If working hours exceed such a benchmark, productivity and wages may start to decline. Such a relationship may have restricted the expansion of working hours in times of increasing wage differentials and even caused working hours to decline. The decrease in working hours may have contributed to the stagnation of the adjusted U wage differentials after 2014. It may indicate, for instance, a higher leisure preference resulting in a decrease in the demand for goods and the stagnation of the U wage differentials.

Although the adjusted wage differentials for U are still higher in 2019 compared to 1996, one may ask whether a period of decreasing wage differentials is ahead and how it might develop. Our empirical approach should be useful for thinking about this question. For West Germany, earlier findings by Gebel and Pfeiffer (2010) suggest that average returns to education between 1984 and 2006 reached a minimum in 1996. The current study suggests that the adjusted U wage differential for university graduates was highest around 2012 and in 2019 was still above the values in 1996. However, the labour market momentum of university expansion is ongoing and there may be room for a further decline in the future. It remains a task for future research to assess the further evolution of educational wage differentials and their underlying forces.

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12651-022-00323-6>.

**Additional file 1: Table S1.** Descriptive statistics from the (pooled) estimation samples, 1996 to 2019 (Total/Women/Men). **Table S2.** Average real wages by educational degrees, 1996 to 2019 (Women/Men; Mean). **Table S3.** Average real wages and annual wage growth by educational degrees (Women/Men; in EUR and in %). **Table S4.** Educational wage differentials, 1996 to 2019 (Women/Men; in Ln, [CII]). **Table S5.** Dynamics of degrees and subject-specific wage differentials (in thousands/in %).

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## Author contributions

All authors read and approved the final manuscript.

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## Availability of data and materials

The dataset analysed during the current study is available at the Research Data Center of the Socio-Economic Panel, <https://doi.org/10.5684/soep.core.v36>. The additional statistical information is based on data of Destatis and is available at <https://iceland.dzhw.eu>.

## Declarations

### Ethics approval and consent to participate

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

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