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Gender overeducation gap in the digital age: Can spatial flexibility through working from home close the gap?

Ana Santiago-Vela *, Alexandra Mergener

Federal Institute for Vocational Education and Training (BIBB), Division "Qualifications, Occupational Integration and Employment", Robert-Schuman-Platz 3, 53175, Bonn, Germany

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ABSTRACT

This study analyses the gender overeducation gap, meaning differences between partnered men and women in the degree of holding a job with lower requirements compared to one's own education, and how working from home (WfH) affects overeducation. Contextualising education–job mismatches in the digital age, we update an old topic of labour market research considering new options of spatial flexibility via WfH. Using a unique German dataset of the core employed population in 2018 (i.e., individuals that are at least 15 years old and report paid work for at least 10 h per week), our results show a gender overeducation gap, with women at a higher risk of overeducation than men. By applying a latent variable approach with simultaneous regressions to account for potential selection into jobs allowing WfH, we find that the WfH option carries a lower overeducation risk. Moreover, the findings suggest a gender-specific benefit of WfH: women show higher overeducation risks among employees without the WfH option, but the gender overeducation gap is closed among those with the WfH option.

1. Introduction

The study of *overeducation* has a long tradition in economic and sociological research (e.g., Borgna, et al., 2019; Hartog, 2000; Levels et al., 2014; Pollmann-Schult and Büchel, 2004; Verhaest and Van der Velden, 2013; Voβemer and Schuck, 2016).[1] Being overeducated indicates a vertical mismatch between education and job position and is defined as working in a job with a lower required educational level than one's own attained educational level (e.g., McGuinness, 2006).

The vast majority of studies show that women are more often overeducated for their jobs than men (e.g., Boll and Leppin, 2016; Büchel, 1996; Büchel, 2001; Daly et al., 2000; Leuven and Oosterbeek, 2011). To explain the gender difference in overeducation rates, we rely on the seminal theory of differential overqualification (Frank, 1978), which uses the concept of local labour markets (LLMs) to explain education–job (dis)placements by priorities for job choices. According to this theoretical approach, partnered men's job choices are traditionally more likely to take precedence, while partnered women are more constrained than men and tend to make the decision depending on their partner's job placement. Thus, partnered women are more likely to embody traditional gender roles and more often constrained to the job market near their place of residence (i.e., the LLM). This limits the supply of jobs, leading to more difficulties finding a job that matches workers' qualifications and thereby to higher overeducation rates for partnered women (Büchel

* Corresponding author.
E-mail address: santiagovela@bibb.de (A. Santiago-Vela).

[1] Studies use several terms to describe the phenomenon of vertical mismatch such as overeducation or overqualification. In this study, we use overeducation and overqualification interchangeably.

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and Battu, 2003). Conversely, the risk of being overeducated for a job decreases if people consider not only the local but also the supraregional market for a suitable job and, hence, are spatially flexible.

The digital age is exposing labour markets to profound transformations that are creating new paradigms for old labour market issues – including overeducation. Particularly in the digital age, spatial flexibility plays an important role in labour markets. Increasing opportunities for digital networking and the use of information and communication technologies (ICT) or data clouds render the possibility to work outside company workplaces and thus also from home (Eurofound and the International Labour Office, 2017; Messenger and Gschwind, 2016). Working from Home (WfH) contributes to spatial flexibility by dissolving the strong ties between place of residence and employer's premises. WfH enables employees to substitute working time they would typically spend at an employer's premises with working time spent at home (Allen et al., 2015) and, hence, to be employed in jobs based further from their LLM. WfH reduces the costs of going beyond the LLM. This can increase employees' chances of finding a job that matches their educational level, particularly for partnered women, who have traditionally been less spatially flexible due to partnership ties.

Bringing these aspects together, this paper focuses on the gender overeducation gap for partnered employees in the digital age, posing the *research question* of whether the WfH option may help in closing the gender overeducation gap. We focus on the German labour market, where in despite of the structured assignments of qualification profiles to job positions (Solga and Konietzka, 2000), a significant proportion of qualification-job mismatch exists. The proportion of overeducated employees reached about 21 percent in 2018 (Santiago-Vela, 2021). Moreover, in the same year, around 28 percent of all German employees worked from home, while 57 percent had the option to carry out their occupational tasks from home (Mergener, 2020).

The contribution of the present study is manifold. First, contextualising work and education–job mismatches within the digital age, we are updating an old topic of labour market research integrating essential, new digital transformations on the labour market. To our knowledge, this is the first study to consider WfH as a new way of spatial flexibility, analysing its effects on the overeducation risk. Second, whereas previous studies for Germany confirmed Frank's theory of differential overqualification for men and women (Boll and Leppin, 2016) and the importance of including spatial context as determinant of overeducation (Büchel and Battu, 2003), this is the first study exploring whether the possibility of opening LLM by WfH influences the gender overeducation gap. Third, using the German BIBB/BAuA Employment Survey 2018, we are enhancing the overeducation research with findings that are based on high-quality data. The data allow us to operationalise WfH in a more differentiated way than any other comparable data set by identifying not only the use of WfH but also whether the job actually allows for WfH. In so doing, we acknowledge that the selection into the WfH option necessarily precedes the use of WfH. Our empirical strategy adjusts for selection into the WfH option and overeducation to avoid a spurious association between this option of spatial flexibility and adequate jobs (good education–job matches), which is a novel method that has not been applied thus far to studies on WfH.

Bringing together overeducation with WfH research, our findings present first evidence on the gender-specific consequences of spatial flexibility in the context of digital transformations of labour markets, hence providing a new focus that should be considered when designing labour market policies. Our insights may be especially valuable, since WfH experienced a sudden increase in Germany during the COVID-19 pandemic (e.g., Frodermann, et al., 2020).

2. Theoretical considerations

2.1. Gender-specific spatial flexibility and overeducation

The long tradition in overeducation research has highlighted the relevance of considering spatial factors when analysing possible determinants of overeducation. Employment opportunities are restricted by limited spatial flexibility, and with this, the possibilities of making education-to-job matches. The theory of differential overqualification, developed by Frank (1978) in his seminal work, made use of married women's constrained geographical flexibility in job search behaviour to explain higher observed overeducation rates among them. This analysis was the first focusing on the spatial determinants of overeducation. Further studies developed this theoretical framework, analysing the role of partnership status and gender for overeducation (see Büchel and Battu, 2003 for Germany or, McGoldrick and Robst, 1996 for USA). In addition, Boll and Leppin (2016) made an essential contribution by expanding the differential overqualification theory for Germany to its economic returns, concluding that women are more likely to be overeducated but they have lower wage penalties from overeducation.

From a theoretical perspective, job seekers located in a given geographic location are faced with the decision of looking for and finding a job near the place of residence (i.e., within their LLM). As LLM characteristics' determine employment opportunities, there are several alternatives in case the LLM does not provide for a job matching the educational level. Job seekers can move to a place where a matched job is available (i.e., change the LLM), commute between place of residence and workplace, be (or stay) overeducated in the place of residence or keep seeking employment while unemployed. Thereby, geographic restrictions and possibilities of opening the possibly restricting LLM determine education-job matches of employees (Büchel and Van Ham, 2003).

Assuming this theoretical link between overeducation and spatial flexibility, attention has been drawn to the relevance of partnership in the job seeking process, since regional coordination of the partners' careers become more problematic. Compared to single job seekers, the job search process of partnered job seekers in dual earner households needs to be coordinated and different interests may need to be considered in the matching process. If it is not possible for both to find an adequate job in the same location, one of the partners has to make concessions, taking the role of tied mover or tied stayer.

Following this reasoning, evaluated in the context of the economic household theory (Mincer, 1978), one can predict that in the process of optimisation at the household level, household members make geographical decisions about the place of residence by evaluating the costs and benefits of moving or staying collectively. Being a tied mover or tied stayer is related to costs coming from

flexibility constraints that make optimal employment chances more difficult. Thus, the calculation procedure for residence decisions at the household level permits one household member to improve the optimal job opportunities while limiting the job optimisation of the other household member. The assumption that individuals in dual earner partnerships consider only collective interests in migration decisions has been further developed by bargaining theories. The argument is that these decisions resemble a bargaining process in which individual interests of the members of a couple and bargaining power are decisive for final decisions (Abraham et al., 2010). However, even if household members do not decide on place of residence exclusively collectively, but with individual interests in mind, there is always some trade-off in dual earner couples at the cost of individual job prospects, mainly on the side of secondary earners.

In this sense, research has repeatedly reported gender differences in partnerships' geographical decisions, which is primarily explained by the fact that women have more often taken the role of secondary earners (Blau and Kahn, 2003) and accordingly of tied movers or tied stayers, while men as predominantly first earners have tended to optimise their job choices (Frank, 1978; Mincer, 1978). Recent research again confirms that this partner pay gap is not declining and women still earn substantially less (Dieckhoff et al., 2020). An unequal share of paid work between partners can also lead to a gendered division of housework, as women tend to adjust their housework in relation to their share of paid work (i.e., they do more housework when they have less paid work than their partner) (Auspurg et al., 2017). Moreover, in dual earner partnerships, women are typically more involved than men in performing housework or childcare (Pailhé et al., 2019), which reflects both power relationships based on higher earnings of men and existing gender roles. Following arguments based on sociological gender role approaches (e.g., Bielby and Bielby, 1992; Jürges, 2006), men tend to act as breadwinners, and women tend to identify more with their role in the household and family responsibilities than with their career. Unpaid work in the household is subject to gender-specific expectations causing primarily women to take care of housework or family obligations (Hochschild and Machung, 2012). By conforming to these normative expectations, men and women are doing gender (West and Zimmerman, 1987), with men more likely to focus on careers and to pursue well-matched jobs than women.

Additionally, gender inequalities in the geographical job decision-making within couples have been theoretically related to women's lower willingness to move for a job (Abraham et al., 2019). This applies in particular to married couples, for whom a closer relationship can be assumed through the contractual basis (Brines and Joyner, 1999; Lyngstad et al., 2011). Moreover, some societies have wage tax guidelines for joint taxation of married couples, which allow for the maximisation of collective income especially when the two individual incomes are substantially different. In this sense, in Germany, the so called Ehegattensplitting (i.e., income splitting) provides incentives for income specialisation of the household member with higher earnings, while the member with lower earnings does not need to make a high monetary contribution (i.e., to work more hours) in order to maximise net household income.

Consequently, women as tied movers or tied stayers tend to suffer significant economic disadvantages in terms of labour market participation, extent of working time, income (Cooke, 2008; Geist and McManus, 2012; Mincer, 1978), and education–job mismatch. Since partnered women mainly seek employment after a move has been completed (Cooke, 2008), they more often constrain their decisions to the LLM where their partner is working. This spatial restriction results in a limited number of vacancy options in general and so in a limited number of jobs corresponding to the individual level of qualification. Hence, there is a higher risk of working in a job that typically requires a lower qualification (i.e., overeducation), which is even more acute if the other household member has chosen a small LLM where only limited jobs opportunities are available (Büchel and Battu, 2003).

2.2. WfH as an expression of spatial flexibility in modern labour markets

If limited spatial flexibility increases the risk of overeducation, being spatially flexible therefore should enhance the chance for jobs that corresponds to workers' education. Especially in modern labour markets, new opportunities for spatial flexibility are emerging beyond moving or daily commuting. By using ICT, work is getting more portable. Data clouds or digital networks allow both access to relevant work content and networking among employees mainly independent of employers' locations. The use of mobile ICT offers spatial flexibility by making WfH possible (Daniels et al., 2001; Pérez et al., 2002; Sarbu, 2015). WfH (or home-based telework, telecommuting) means that employees perform the work for the employer at least temporarily from home and thus includes alternating work between the employer's premise and private home as well as working exclusively from home (Sullivan, 2003). Through this work practice, employees can substitute working hours they would typically spend physically at the employer's location or office with working hours they spend at home (Allen et al., 2015). As a result, employees using WfH are able to work for employers geographically further away from their place of residence (e.g., Mergener and Mansfeld, 2021; Rüger et al., 2021), as they have the possibility of reducing the number of commuting trips (e.g., Mokhtarian, et al., 2004; Ravalet and Rérat, 2019). This means of spatial flexibility facilitates performing a job for an employer that is not located directly at the place of residence, reducing costs for job decisions and thus allowing for opening the LLM.

2.3. WfH and overeducation: Can women benefit?

The opening of the LLM through WfH should decrease the overeducation risk. By broadening the range of possibilities in the job seeking process, employees can improve their chances of finding a job that matches their individual level of qualification (e.g., Abel and Deitz, 2015; Petrongolo and Pissarides, 2006).

According to the arguments of gender-specific spatial flexibility, WfH should be particularly beneficial for partnered women. While partnered women as tied movers or tied stayers adapt their choice of place of residence to their partners' workplace choices, the opportunity of taking a job outside their place of residence by using WfH should be more relevant in reducing their risk of overeducation than that of men. Partnered men tend to be more spatially flexible in deciding on a job that matches their qualification.

Furthermore, women are typically more involved in housework, which also limits the time they can spend commuting (Nisic, 2017) and is in line with the pattern of shorter commutes for women than for men in Germany (Rüger et al., 2012). Partnered women repeatedly report that they work closer to home than men (Rapino and Cooke, 2011; Rouwendal, 1999), since they usually have to integrate shopping or errands into their work trips (Crane, 2007; Johnston-Anumonwo, 1992). In order to improve the work-life balance, women may even tend to occupationally downgrade themselves resulting in higher overeducation rates (Davia et al., 2017). Yet, WfH allows women to work in jobs even when there is a greater distance between the employer and the home by saving time on daily commuting. This form of spatial flexibility allows the combination of family life and household responsibilities with intellectually challenging and satisfying jobs and leads to increased career chances for women with family responsibilities (Perrons, 2003). Moreover, WfH may promote maintenance of women's employment (Kleemann, 2005), lead to higher wages (Weeden, 2005) and even reduce gender-specific income inequalities – at least if it is implemented in the company as an instrument for balancing work and family life (Abendroth and Diewald, 2019).

2.4. Hypotheses

According to the assumptions of gender-specific spatial flexibility in partnerships:

H1. *We expect a gender overeducation gap, that is, a greater likelihood of partnered women than partnered men being overeducated for their jobs.*

Contextualising work in the digital age, we consider WfH as a way of spatial flexibility to open LLMs. Following the reasoning of the important role of flexibility and LLMs in the education–job matching, this option of spatially flexible work can lead to a higher chance of finding and performing a job that matches workers' qualifications but is outside their place of residence. For that reason:

H2. *We assume that employees who have the WfH option show a lower rate of overeducation.*

Bringing these two aspects together while at the same time assuming that partnered women have more constraints on their flexibility than do partnered men:

H3. *We expect that the gender overeducation gap largely depends on WfH, so that the gap will be significantly smaller for partnered employees who do not have the WfH option.*

3. Data, variables, and analytical strategy

3.1. Data

We analysed data from the Employment Survey 2018 of the Federal Institute for Vocational Education and Training (Bundesinstitut für Berufsbildung, BIBB) and the Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, BAuA) (Hall et al., 2020). The BIBB/BAuA Employement Survey 2018 is a large-scale representative survey of the core employed population in Germany (i.e., individuals that are at least 15 years old and report paid work for at least 10 h per week) and was conducted with two comparable sampling frames referring to the same population, which were merged subsequently based on a design weighting to form a representative sample of the core employed population in Germany (Rohrbach-Schmidt and Hall, 2020). The BIBB/BAuA Employment Survey offers unique potential for addressing the hypotheses raised in this paper, as no other dataset contains comparably rich and detailed information on employees' education and employment histories, career aspirations, highly disaggregated occupations, job requirements, and other workplace characteristics such as differentiated information about WfH. To consider the spatial context in our analyses, we specified different LLMs matching indicators at a highly disaggregated regional level (small-scale official district codes or Kreiskennziffer, KKZ) from official statistics of the Federal Institute for Research on Building, Urban Affairs, and Spatial Development (Bundesamt für Bauwesen und Raumordnung, BBSR) (BBSR, 2019).

Beginning with the full BIBB/BAuA Employment Survey of more than 20,000 core employed individuals, we first restricted the sample to employees (17,884 persons) and excluded the 2,128 freelancers and self-employed persons covered in the dataset. This restriction of the sample was necessary given our focus on the WfH option, which is conceptualized as a work practice that enables employees to perform work for the employer from home. As self-employed individuals and freelancers lack formal employers to provide them with this option, they did not reply to the question about whether they work from home. Hence, there is no WfH information available in the data for people who identified as self-employed or freelancers.

In a second restriction of the sample, we further limited our analyses to partnered employees (a sample of 11,784 persons remained). This additional restriction to partnered employees was necessary to follow more closely our theoretical arguments, which focus on education-job placements in partnerships and spatial flexibility constraints of partnered employees. We defined partnered employees as employees in cohabitation unions instead of using the more common but more restrictive definition of marriage. In so doing, we allowed for variability in sample composition and avoided a selective sample of married employees who are on average older and less likely to have an academic degree. Moreover, we considered partnered employees aged 20 to 65 because younger individuals rarely live in cohabitation unions and older individuals rarely participate in the labour market.

In a last restriction, we applied a listwise deletion of observations with missing data on any control variable within the sample of partnered employees (i.e. employees in cohabitation unions aged 20–65 years old). This restriction left us with a final analytic sample of 9,549 employees aged 20–65 years and in cohabitation unions with full information on all variables.

However, a risk of listwise deletion is that it may result in a final analytic sample that does not resemble the population of partnered employees. To ensure that listwise deletion did not lead to a biased final analytic sample relative to the overall sample of employees aged 20–65 years and in cohabitation unions, we compared weighted distributions[2] of variables across both samples (see Appendix Table A1). We found no meaningful differences across the samples. Indeed, the population of the final analytic sample resembles the population of partnered employees in terms of overeducation (with a share of 19.63percent and 20.04 percent, respectively), women (with a share of 46.16 percent and 46.38 percent), employees without the option for WfH (with a share of 60.71 percent and 61.59 percent), and all control variables included in the analysis. Thus, the similarities shown in Appendix Table A1 suggest the population of the analytic sample to be used in drawing conclusions for the population of partnered employees aged 20–65 years.

3.2. Variables

3.2.1. Dependent variable: overeducation

Our *dependent variable* refers to overeducation and is based on workers' self-assessments. We compared workers' assessments of the level of education that is required to perform their job with the employees' actual educational level. For the assessment of the required educational level, workers were asked "What type of training is usually required for performing your current job? A completed vocational training, a university of applied sciences degree or university degree, an advanced training degree, e.g., as a master craftsman or technician, or is no vocational training degree required?" If the educational level acquired by workers is higher than the education level required at their workplace, they were classified as overeducated.[3]

Since no consensus exists on the measurement of overeducation, there are several viable approaches (Capsada-Munsech, 2019). The main critique to subjective approaches for the measurement of overeducation is based on the possible measurement error due to social desirability, especially if workers overstate their job requirements (Leuven and Oosterbeek, 2011). However, compared to the alternative objective approaches based on job experts' analysis or on statistical distributions of educational levels within occupations, workers' self-assessments have the advantage of considering heterogeneity at the workplace level and acknowledging that jobs differ within the same occupational groups (Hartog, 2000; McGuinness, 2006).[4] In addition, our subjective approach is an indirect assessment of the overeducation status, since workers assess the educational level requirement and do not directly evaluate their education-job mismatch itself. It is reasonable to argue that accounting for this wording effect through indirect self-assessments is a good strategy to produce a robust measure for overeducation (Büchel, 1998). Another strength of our overeducation indicator stems from the question measuring the required educational level. This question refers to the educational level "to perform/to do the job" and is less sensitive to credential inflation than other alternatives referring to the needed level "to get the job" (Hartog, 2000).

3.2.2. Independent variables: gender and WfH

Gender is a dichotomous variable, with men as the reference category. We built the variable WfH based on a two-step procedure. In a first step, we measure the WfH option, that is, whether employees are allowed by their occupation or employer to WfH. In a second step, for employees with the WfH option, we further differentiate whether they use WfH or decide against the WfH option. Consequently, we differentiated three categories of employees with WfH options—those deciding against WfH, those using WfH as work time and those using WfH as overtime—which we compare to the reference category of not having the WfH option because the occupation or employer does not allow.

First, the lack of WfH options is the main structural difference introducing selection between groups: employees who do not work from home because their occupation or employer does not allow it are excluded from the WfH option and thus, do not have the chance to open LLM using this as a means of spatial flexibility. Differentiating between employees with and without the WfH option is crucial because the possibility of performing a job that matches employees' qualifications but is outside their place of residence is first given by the WfH option rather than by the use of WfH. The WfH option is thus a pivotal dimension underlying the theoretical arguments of spatial flexibility and LLM explored in the present study.

Second, we differentiate the three groups of employees with the WfH option to acknowledge the heterogeneity of employees with the WfH option. It is reasonable to argue that employees who decide not to work from home should be highly selective. One could

[2] Possible sources of selectivity limiting representativeness (e.g., lack of access to respondents in the core employed population, non-response of interviewees) were corrected by an adjustment weight, i.e., by calibrating the sample structures to those of the population with weighting factors. These weighting factors were based on official data from the German Microcensus 2017, which represent by convention the population in Germany and refer to the characteristics age, gender, education, nationality, occupational status, marital status, household size, and place of residence (Rohrbach-Schmidt and Hall, 2020). By calibrating the sample to those of the German population with weighting factors, the BIBB/BAuA Employment Survey is considered representative of the core employed population in Germany with respect to these factors (for further details, see Gensicke and Tschersich, 2018).

[3] If workers acquired several degrees, the degree with the highest level is considered. In case a worker acquired several degrees within the same level, the most recently acquired degree is considered.

[4] The subjective method will be more conservative than objective methods for evaluating gender differences if women are more prone to underestimate their workplace requirements. As it is impossible to stipulate the "correct" requirement level of a job, we evaluated the benefits of considering workplace heterogeneity within the same occupational titles when measuring job requirements. Assuming heterogeneous patterns when evaluating workplace requirements between men and women (more concretely, assuming an inclination of women to underrate requirements of their job), the subjective approach of measuring overeducation would lead to a downward bias in women's overeducation rates.

assume that this group of employees does not need the spatial flexibility offered by WfH because they are already very flexible, and perhaps they have already moved close to their workplace.[5] We do not expect any gender overeducation gap within this group, since these employees already exclude themselves from the treatment effect of more spatial flexibility. In addition, the group of WfH users is differentiated depending on the contractual regulation of home working hours. WfH can be contractually recognised by employers as working time or may occur supplementary to the time worked in the company and therefore be regarded as "overtime" WfH. This detailed differentiation in measuring the WfH option and its use is a major strength of the present study. Most previous studies on effects of WfH (can) only distinguish between WfH and not WfH (e.g., Abendroth and Reimann, 2018; Kurowska, 2018; Peters et al., 2009).

To ensure that WfH can be considered as a means of flexibility allowing for opening LLM, we additionally investigated both the association between WfH and opening the LLM as well as the association between opening the LLM and overeducation among employees in cohabitation unions (Appendix Tables A1 and A2). By using the methodologically elaborate assignment of labour market regions for Germany by Kropp and Schwengler (2011) and regional indicators of the German Federal Employment Agency for 2018, we identified LLM regions for place of residence and employer location. Workers are considered to have opened their LLM if the region of the residence differed from the region of employer location. The findings confirm that WfH users are, on average, more likely to open their LLM than employees without the WfH option, and that this pattern applies for both men and women (Appendix Table A2). Moreover, we can show that both women and men in cohabitation unions who opened their LLM are, on average, less likely to be overeducated than those employees who remained in their LLM (Appendix Table A3). Both associations are in line with our main assumption that WfH can ease access to larger labour market regions and provide better chances for a job that matches employees' qualifications level.

3.2.3. Control variables

Our analyses included several *controls at the individual and LLM level*. As individual confounders, we controlled for the final school grades (evaluations) and educational level. On one hand, educational level affects the risk of overeducation, with academic degrees leading to higher risks in Germany (Santiago-Vela, 2021). Highly educated employees are also more likely to hold jobs allowing WfH (Mergener and Winnige, 2021). On the other hand, accounting for the final school grades is a proxy for employees' heterogeneous abilities within the same degree level (Büchel and Pollmann-Schult, 2004; McGuinness, 2006).

Additionally, we introduced information about the leadership position (level of management) of the job and about career aspiration through a dummy for employees who strongly pursue the goal of a career, in order to reduce unobserved variation of motivation and job features that explain overeducation and WfH options. The inclusion of career aspiration is crucial in our identification strategy and captures a confounding factor that has not been considered in previous studies. By presenting results of overeducation while controlling for employees who strongly pursue the goal of a career, the analysis uncovers relationships among gender, WfH, and adequate jobs that cannot be explained by differences in the self-rated career orientation. This is important because preferences for career orientation are assumed to vary between women and men (Hakim, 2000) and are pivotal in explaining gender-specific overeducation risks (Hamjediers and Schmelzer, 2021). Moreover, leadership position is an important factor that explains WfH options and captures job quality, thus affecting the likelihood of adequate jobs.

To account for different employment patterns of partnered men and women, we further considered a dummy for part-time work (less than 20 h per week). Years of tenure was also included as a variable in the models, since employers might be more prone to offer WfH options to senior workers (who have long histories with the employer) on basis of mutual trust, as well as adequate jobs. Employer size was also expected to affect the likelihood of overeducation as well as jobs offering WfH options.

We also control for socio-demographic characteristics of workers as potential confounders: age groups, migration background (Nieto et al., 2015), and socio-economic background (Santiago-Vela, 2021). The indicator for socio-economic background is based on parental occupational status according to the Erikson–Goldthorpe–Portocarero class schema (EGP class schema) developed by Erikson et al. (1979) (see also Erikson and Goldthorpe, 1992), and differentiated whether parental households belonged to the EGP I (high salariat) versus to other, less privileged classes. The presence of children in the household (differentiating whether children are of pre-school age) and partner's employment status (employed versus not employed) might also constitute gender differences in selection into overeducation and WfH, and are thus included in the analyses. In order to control for occupation-level heterogeneity and given the relevance in explaining options for WfH and education–job mismatches (Rohrbach-Schmidt and Tiemann, 2016), we considered workers' occupations (at the 2-digit level of the German Classification of Occupations, Klassifikation der Berufe KldB, 2010).

For our *spatial context*, we identified two main characteristics of LLMs that theoretically affect WfH and spatial flexibility as well as mismatch probabilities (e.g., Büchel and Van Ham, 2003; Croce and Ghignoni, 2015; Hensen et al., 2009): employment rate and agglomeration type. The employment rate is a continuous variable measuring proportion of inhabitants and employed persons in the year 2015. The agglomeration type is a categorical variable for 2015 differentiating cities (with more than 100,000 inhabitants, high population density areas (with more than 300 inhabitants/km^2), medium population density areas (with 150 inhabitants/km^2 or more) and rural areas (with less than 150 inhabitants/km^2). These characteristics were measured at the level of small-scale official district codes (KKZ) and were matched from official statistics (BBSR, 2019) to the main data set of BIBB/BAuA Employment Survey 2018.

[5] This theoretical assumption cannot be empirically tested with our data set, as it only contains information of placement of the current job and it lacks information on moves between regions and reasons for these moves.

3.3. Analytical strategy

To test whether there is a gender overeducation gap (H1), we applied logistic models for the dichotomised outcome of overeducation. To account for clustering in the assignment of overeducation in LLMs, we clustered standard errors at the LLM level (which we specified with small-scale official district codes, KKZ) (Abadie et al., 2017; Cameron and Miller, 2015; Wooldridge, 2002). The models included the control variables in order to address confounding between gender, WfH and education-job match; model 1 only included gender as an independent variable and model 2 additionally controlled for options to WfH. To interpret and compare the regression coefficients, we compute average marginal effects (AME) (Mood, 2010), which represent the independent variable's effect on predicting overeducation.

To test H2, we followed a series of steps. First, we applied logit and probit models of the WfH option on overeducation, controlling for all observed confounders. Even though the analyses used a rich set of important control variables that represent a major improvement relative to previous studies, unobserved factors may induce spurious associations between jobs that allow for WfH and overeducation risks, leading to biased results.[6] To model the potential selection-based endogeneity of WfH options, we rely on a latent variable outcome approach and consider overeducation as the outcome variable. The latent variable outcome model consists of a system of simultaneous regressions for two latent (unobserved) variable outcomes (i.e., overeducation and WfH option) with a shared random effect ε_i for both regressions (Miranda and Rabe-Hesketh, 2006; Rabe-Hesketh et al., 2004). This random effect is introduced in the equations to induce a correlation between the error terms of both equations, so that unobserved common causes of overeducation and WfH option can be modeled.

More formally, the outcome $Over_i$ of the ith individual (overeducation) is always observed, and it depends on the potential endogenous variable $Owfh_i$ (WfH option) and a $K \times 1$ vector of explanatory variables, x_i. The potential endogenous variable $Owfh_i$ is also always observed and it depends on an $L \times 1$ vector of explanatory variables, z_i. Moreover, the system of equations for the latent, unobserved outcomes read as follows:

$$Over_i^* = x_i'\beta + \theta Owfh_i + u_i \tag{1}$$

$$Over_i = \begin{cases} 1 \; if \; Over_i^* > 0 \\ 0 \quad otherwise \end{cases} \tag{2}$$

$$Owfh_i^* = z_i'\gamma + v_i \tag{3}$$

$$Owfh_i = \begin{cases} 1 \; if \; Owfh_i^* > 0 \\ 0 \quad otherwise \end{cases} \tag{4}$$

where $Over_i^*$ represents a latent continuous variable for the tendency to be overeducated, β represents a $K \times 1$ vector of parameters to be estimated, θ is the coefficient associated with the potential endogenous variable, and u_i is a residual term. Similarly, $Owfh_i^*$ represents a latent continuous variable for the tendency for having the WfH option, γ an $L \times 1$ vector of parameters of explanatory variables, and v_i a residual term. Moreover, a shared random effect ε_i is included in both regressions to induce a correlation between the error terms u_i and v_i, that is, to represent unobserved common confounders of overeducation and the WfH options.

$$u_i = \lambda\varepsilon_i + \tau_i \tag{5}$$

$$v_i = \varepsilon_i + \varsigma_i \tag{6}$$

We specified both probit and logit models for our system of simultaneous equations.

First, to specify a probit model, a bivariate normal distribution for u_i and v_i is assumed. Furthermore, ε_i, τ_i, and ς_i are assumed to be normally distributed with mean of 0 and variance of 1, and independent from each other. λ is the only free parameter to be identified, given the information on the correlation ρ between both error terms, whereas the variances of τ_i and ς_i are not identifiable for probit models.

The resulting covariance matrix of the residuals and the correlation ρ follow:

$$Cov\left\{(u_i,\ v_i)'\right\} = \begin{pmatrix} \lambda^2 + 1 & \lambda \\ \lambda & 2 \end{pmatrix} \tag{7}$$

[6] Nevertheless, an appropriate empirical strategy to test for potential endogeneity is not straightforward given the need to use nonlinear models for the dichotomous outcome (Miranda and Rabe-Hesketh, 2006). Whereas previous studies have traditionally relied on two-stage regression strategies to address selection problems (Heckman, 1978, 1979), extrapolating those strategies for continuous outcome variables to dichotomous outcomes may lead to inappropriate distribution results for the estimators and thus, to wrong conclusions (Heckman, 1978; Wooldridge, 2002). Hence, we followed recommendations for the alternative use of maximum likelihood techniques or the two-stage method of moments (Miranda and Rabe-Hesketh, 2006; Rabe-Hesketh et al., 2004).

$$\rho = \frac{\lambda}{\sqrt{2(\lambda^2+1)}} \tag{8}$$

Due to the shared random effect ε_i, the parameterisation differs from that typically used for probit models without correlated error terms where the variances are assumed to equal 1. To convert the simultaneous probit regressions to the usual parameterisation, we rescaled the estimated regression coefficients and multiplied the parameters of equation (1) by $\frac{1}{\sqrt{\lambda^2+1}}$ and the parameters of equation (3) by $\frac{1}{\sqrt{2}}$.

Second, to specify a logit model, we set the error term u_i to be logistically distributed with variance $\frac{\pi^2}{3}$. Given that the shared random effect ε_i cannot be specified as having a logistic distribution, we approximated a logit model by specifying a logistic distribution for τ_i and rescaled the parameters of β and θ from (1) using the rescaling factor $\frac{\sqrt{\frac{\pi^2}{3}}}{\sqrt{\frac{\lambda^2+\frac{\pi^2}{3}}{3}}}$.

The parameter ρ stands for the correlation between the error terms from the equations of overeducation and WfH option. A high correlation would be indicative of a strong interrelatedness in the confounders of overeducation and the WfH option leading to spurious correlations, so that results neglecting selection into WfH options would be strongly driven by unobserved characteristics. In other words, an endogenous selection into WfH options would imply that unobserved characteristics simultaneously affect the likelihood of having a job that allows WfH and the likelihood of being overeducated. On the contrary, there would be no correlation between both error terms if ρ equals 0, and thus, no selection into WfH options could be assumed. To test the null hypothesis that $\rho = 0$, that is, that overeducation and WfH option do not share unobserved common causes, we applied likelihood ratio tests.

To identify equations (1) and (3), we included the variable overeducation, two indicators of WfH options (one for women and for men), and the regular control variables for the vector of explanatory variables x_i'. Meanwhile, for the vector of explanatory variables z_i' from equation (3), we considered a different list of explanatory variables for WfH options to increase the precision of the shared random effect ε_i: age, having an academic degree, presence of children in household differentiating by age, part-time work (<20 h/week), years of tenure, employer size, leadership position, migration background, socio-economic background (EGP I, high salariat), and occupations (2-digit of the KldB, 2010). Most important, we included an additional explanatory variable as an exclusion restriction—that is, a variable that may predict the potential endogenous WfH option but is assumed to not directly affect the dependent variable of overeducation. Even though specifying at least one exclusion restriction is not strictly necessary (Heckman, 1978) and vectors x_i' and z_i' may contain identical explanatory variables, this additional exclusion restriction helps to identify the model (Miranda and Rabe-Hesketh, 2006).

Hence, we assessed the nature of the tasks performed at the workplace, focusing on the manual components as defined in the task approach of Autor et al. (2003). For the operationalisation, we follow the categorisation of Rohrbach-Schmidt and Tiemann (2013) to bundle employees' self-reported single tasks into manual tasks (e.g., manufacturing, repairing, taking care and healing, cleaning) and non-manual tasks (e.g., organising, consulting, promoting, researching), and subsequently defined a dummy variable that measured whether the main tasks that employees perform at work were predominantly manual (Alda, 2013).

We argue that the WfH option is mainly determined by the tasks performed at work, so that jobs that predominantly require performing manual tasks do not easily allow the WfH option. We further argue that this categorisation is focused exclusively on capturing the feasibility to perform a job outside employer premises. In this sense, manual tasks usually require specialised materials found on the employer premises and are thus cannot be performed from home. Alternative task categorisations (e.g., routine vs. non-routine tasks) may capture other dimensions such as repetitiveness that do not relate to the feasibility of spatial flexibility (Mergener, 2020). Thus, juxtaposing manual vs. non-manual tasks intends to measure the nature of the job tasks that drives the WfH option. Furthermore, the manual or non-manual component of job tasks should not clearly determine the overeducation risk per se, but only in combination with other task dimensions such as repetitiveness (Rohrbach-Schmidt and Tiemann, 2016). Because manual tasks are measured at the workplace level and not derived from employees' occupational group, our indicator on manual tasks encompasses heterogeneous workplaces inside the same occupational classifications.

Finally, to test H3, we considered a logistic regression with interaction effects between gender and the different categories of WfH, also controlling for the confounder variables explained in subsection 3.3. Given recommendations for interpreting interaction effects in logistic models (Buis, 2010), we present the results as marginal effects and as multiplicative effects in form of odds ratios (which take into consideration gender differences in baseline odds).

4. Results

4.1. Descriptive evidence

Table 1 presents distributions of overeducation and WfH by gender.[7] The first row indicates that the incidence of overeducation for employees in cohabitation unions is about 3 percentage points higher for females than males, thereby suggesting a small gender

[7] Appendix Table A4 additionally presents distributions of all control variables used for the analyses by gender and overeducation. For the sake of completeness, Appendix Table A5 shows descriptive statistics differentiated by the four WfH categories, in order to provide information on distributions of individual, job, and spatial characteristics across WfH. Moreover, a correlation matrix for all variables is available upon request.

Table 1
Distribution of overeducation and WfH by gender, and of overeducation according to WfH by gender (percent).

	Men (N = 4,798)	Women (N = 4,751)	Total (N = 9,549)
Overeducation	18.23	21.25**	19.63
WfH			
No WfH option	62.12	59.08*	60.71
WfH option	37.88	40.92*	39.29
devided into:			
[Decided against WfH]	[6.19]	[10.61***]	[8.23]
[WfH work time]	[24.68]	[24.40]	[24.55]
[WfH overtime]	[7.01]	[5.91]	[6.50]
Overeducation			
	Men	Women	Total
WfH			
No WfH option	19.06	24.73***	21.61
WfH option	16.88	16.23	16.57
devided into:			
[Decided against WfH]	[30.25]	[21.52]	[25.05]
[WfH work time]	[13.18]	[13.73]	[13.43]
[WfH overtime]	[18.11]	[17.08]	[17.68]

Notes: Weighted percentages. Mean differences statistically significant with $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. Total sample includes only employees aged 20–65 in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018. Authors' calculations.

overeducation gap.[8] On the one hand, compared to women, men are more often engaged in occupations or working for employers where WfH is not an option. On the other, women are more likely than men to decide against WfH, even if they have the WfH option.[9] Almost 25 percent of both men and women work from home during their work time. WfH overtime is less common than WfH during regular work time, and less equally distributed and more frequent (1 percentage point difference) among men than among their female counterparts (7.01 percent and 5.91 percent, respectively).

Furthermore, focusing on the distribution of overeducation by WfH in the lower part of Table 1, it is clear that overeducation is more common in the group of employees without the WfH option due to occupation or employer (21.61 percent) than in the overall group of employees with the WfH option (16.57 percent). This is in accordance with our arguments embodied in H2 that consider WfH as a way of spatially flexible work that relaxes LLM geographical constraints and facilitates opportunities to find adequate jobs. Directing attention to the gender gap in overeducation, it appears that a large, statistically significant gender difference in overeducation is found for employees lacking the WfH option, whereas the gender differences in overeducation across workers with WfH options are not statistically significant.

This pattern corresponds to our interpretation of WfH as a way of spatial flexibility allowing workers, and especially less spatially flexible workers, to find a job that matches their educational level. Given the reasoning of self-selected spatial flexibility among workers with the WfH option, but who decide against it, we did not expect women being at higher overeducation risks than men among this group.[10] Considering employees who work from home but without contractual recognition of work time (WfH in overtime), important gender differences in overeducation may have been expected, since workers in this group are not flexible during their contractually recognised work time. However, it seems reasonable to assume that the time worked at home is also part of job requirements, even if it is not recognised as such in the contract. In this sense, in jobs with this kind of "extra" time requirements, employees who do not work from home in their free time (i.e., employees without this kind of spatial flexibility) would not be able to meet the job requirements, hence restricting job possibilities and education–job matches.

4.2. Main analyses

4.2.1. The gender-overeducation-gap

In our logistic model 1 (Table 2), we considered gender and control variables to test H1. Women in cohabitation unions were more likely to be overeducated for their current employment than men were, and that finding stood when controlling for different labour market biographies, household situations, workplace characteristics, occupations, career aspirations and final school grades. These

[8] For comparison: the overeducation risk does not differ by genders among employees not living in cohabitation unions. Appendix Table A6 shows distribution of overeducation and WfH by gender for employees not in cohabitation unions.

[9] A well-known motive for rejecting WfH is cultural barriers (Lott and Abendroth, 2020), that is, anticipated career disadvantages and stigmatisations at work when opting for flexible work arrangements. In line with previous research suggesting that women are more likely to face cultural barriers than men (Chung and van der Horst, 2020), gender differences in cultural barriers could be the reason why women in our sample are more likely to decide against WfH than men.

[10] Women are even less often overeducated than men in this group. However, because of the small number of cases in this group, estimates are not very precise (wider confidence intervals). The same complication due to a small number of cases applies to the group of WfH users in overtime.

Table 2
Logit regression models of gender and WfH on overeducation (odds ratio [OR] and average marginal effects [AME]).

	Model 1 (Gender)		Model 2 (Gender + WfH option)	
	OR	AME	OR	AME
Women	1.298*	0.037*	1.280*	0.035*
	(0.149)	(0.016)	(0.147)	(0.016)
No WfH option			*Reference*	
WfH option			0.780**	−0.035**
			(0.073)	(0.013)
Controls	*Yes*		*Yes*	
Observations	9,549		9,549	
Log likelihood	−4,162.029		−4,155.022	
Pseudo R-squared	0.097		0.098	

Standard errors in parentheses. Significance: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.
Notes: Logit models of overeducation with standard errors clustered at small-scale official district codes (KKZ) controlling for employees' age, migration, and socio-economic background (EGP I, high salariat), career aspiration, children in household, academic degree, final school grades, part-time work, job leadership position, tenure (years), employment of partner, occupation (KldB, 2010, 2-digit), employer firm size, agglomeration type, and employment rate measured at KKZ level for the year 2015. Weighted results. Total sample includes only employees aged 20–65 and in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018. Authors' calculations.

results are consistent with our arguments for gender-specific geographical flexibility within partnered employees and they confirm H1.

When also adjusting for having the WfH option (Table 2, model 2), the gender effect for employees in cohabitation unions slightly diminished. This was expected given that having the WfH option is negatively associated with overeducation risks and that men are more often engaged in occupations or with employers where WfH is not an option. Hence, women have on average a 3-percentage point higher probability of being overeducated in their current employment than men.

4.2.2. WfH option and overeducation

The logistic regression that does not consider potential selection into the WfH option but that adjusts for all observed confounders (Table 3, model 3) suggested a negative association between risks of overeducation and women and men having the WfH option. The negative and statistically significant coefficient of WfH options for women (men) indicates that the risk of overeducation is lower for women (men) with jobs allowing the WfH option than for women (men) in jobs without this option. However, the associations may be spurious if there is non-random selection into jobs offering the WfH option. We account for a wide range of common causes for WfH and overeducation as individual preferences and job characteristics to minimise the risk of unobserved characteristics inducing selection into WfH option. We rely on information about the strength of employees' career aspirations as a proxy for career orientation. This career aspiration differs between men and women and is crucial to explain gender-specific overeducation (Hamjediers and Schmelzer, 2021). Further, we control for occupations and ability by using final school grades (evaluations) as a proxy. The job's leadership position is also an important common cause of adequate jobs and of WfH and might reflect different levels of job complexity and autonomy that allow WfH options. Consequently, the WfH effects for men and women are likely not confounded by career-oriented employees selecting themselves into adequate jobs that allow WfH.

Nevertheless, other potential confounders that remain unobserved may still have induced spurious associations between WfH and adequate jobs. Because certain characteristics that capture quality dimensions of jobs may be heterogeneous within occupations (i.e., they are workplace-specific and thus, vary within a given occupational group), adjusting for occupations would only partially resolve the problem. Individual characteristics beyond career orientation and ability captured via final school grades, such as personality traits that enhance productivity, might also have driven the coefficients of both the independent and dependent variables in the logistic regression analyses. In order to assess whether adjusting for a potential selection into a WfH option changes the results, we also incorporate in Table 3 results from simultaneous logit regressions that account for endogenous selection into the WfH option.[11] In so doing, we can compare results with and without adjusting for potential selection. The underlying idea of adjusting for selection bias is that women (men) with jobs offering the WfH option are compared to women (men) with jobs not allowing the WfH option. In this process, after accounting for selection in model 4, women with the WfH option are even less likely to be overeducated than women without the option. The same pattern applies to men: whereas in the model that does not adjust for selection, men with the WfH option are less likely to be overeducated than men without this option of spatial flexibility, adjusting for selection bias increase the negative relationship between WfH option and overeducation risks of men. Both effects of WfH option for men and women are in line with H2 and with our interpretation of the WfH option as a way of spatial flexibility that makes for lower overeducation risks. Hence, women in cohabitation unions benefit from having options to WfH, but also men in cohabitation unions largely benefit. In addition, regarding the

[11] We additionally used the simultaneous probit regressions to test sensitivity of results from the simultaneous logit regressions. Given the similar results from the simultaneous logit and probit regressions and given the overall use of logit regressions to test the remaining hypotheses, we preferred to focus on simultaneous logit regressions. We only reported and discussed results from simultaneous logit regressions (Table 3, model 4), whereas results of the simultaneous probit regressions are available upon request.

Table 3
Logit regressions on overeducation with and without selection into WfH option.

	Model 3	Model 4	
	(Without selection)	(With selection)	
	Overeducation	Overeducation	WfH option
Women	0.199*	0.103	−0.120***
	(0.091)	(0.053)	(0.034)
Women with WfH option	−0.464***	−0.500***	
	(0.085)	(0.077)	
Men with WfH option	−0.507***	−0.542***	
	(0.098)	(0.078)	
Employment rate (KKZ)	−0.038	−0.018	
	(0.053)	(0.031)	
Agglomeration type (KKZ) (Ref. rural area < 150 inhabitants/km^2)			
City (+100.000 inhabitants)	−0.001	−0.012	
	(0.194)	(0.111)	
High pop.-density area (+300 inhabitants/km^2)	−0.094	−0.059	
	(0.109)	(0.063)	
Medium pop.-density area (>150 inhabitants/km^2)	−0.008	−0.007	
	(0.097)	(0.056)	
Partner is employed	−0.011	−0.005	
	(0.075)	(0.043)	
Children (Ref. no children)			
Children in household aged >6years	−0.043	−0.025	0.059
	(0.092)	(0.053)	(0.045)
Children in household aged ≤ 6 years	−0.137	−0.088	0.009
	(0.099)	(0.057)	(0.048)
Children aged >6, but not inhousehold	0.059	0.031	−0.006
	(0.093)	(0.054)	(0.046)
Children aged ≤6 years, but notin household	−0.228	−0.134	0.098
	(0.772)	(0.446)	(0.329)
Age groups (Ref. ≥ 55 years)			
20–34 years	−0.423***	−0.245***	−0.050
	(0.125)	(0.073)	(0.062)
35–44 years	−0.402***	−0.217***	0.076
	(0.109)	(0.064)	(0.054)
45–54 years	−0.206*	−0.116*	0.064
	(0.080)	(0.047)	(0.040)
Academic degree(*Ref. no academic degree*)	0.862***	0.554***	0.604***
	(0.076)	(0.047)	(0.033)
Final school grades (good to very good)	−0.091	−0.054	
	(0.061)	(0.035)	
Socio-economic background (EGP I, high salariat)	−0.078	−0.030	0.156***
	(0.072)	(0.042)	(0.035)
Migration background	0.071	0.048	0.004
	(0.090)	(0.052)	(0.048)
Part-time work (<20 h/week)	0.753***	0.426***	−0.038
	(0.105)	(0.068)	(0.064)
Tenure (years)	−0.023***	−0.013***	0.000
	(0.003)	(0.002)	(0.002)
Leadership position	−0.130*	−0.051	0.253***
	(0.066)	(0.040)	(0.031)
Employer firm size (Ref. 250 + employees)			
1–9 employees	0.137	0.088	0.016
	(0.102)	(0.059)	(0.052)
10–49 employees	0.335***	0.170***	−0.168***
	(0.078)	(0.047)	(0.039)
50–249 employees	0.088	0.035	−0.139***
	(0.076)	(0.044)	(0.037)
Career aspirations	−0.230***	−0.128**	
	(0.069)	(0.041)	
Constant	−0.145	−0.059	−0.719**
	(0.554)	(0.322)	(0.238)
Manual job tasks			−0.547***
			(0.046)
Occupations	yes	yes	yes
λ			381**
			(0.147)
Observations	9549		12928
Log likelihood	−4047.622		−9438.804
Pseudo R-squared	0.100		

Notes: Standard errors in parentheses. Significance: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. Logit coefficients from models of overeducation with robust standard errors. Coefficients in model 4 were rescaled to make them comparable (see subsection 3.3). All models controlled for occupation (KldB, 2010, 2-digit). Total sample includes only employees aged 20–65 and in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018, authors' calculations.

coefficient for women in Table 3, it appears that after adjusting for selection into WfH access in model 4 the coefficient for women decreased, so that is not statistically different from zero.[12]

In summary, the WfH option coefficients slightly increased in absolute values for both men (from −0.507 to −0.542) and women (from −0.464 to −0.500) after accounting for selection in model 4, indicating that some unobserved confounders influence WfH option and overeducation risks. In other words, there is a source of minor self-selection that induces women and men in jobs with the WfH option to also have higher overeducation risks. The value of λ and the derived correlation ρ term in the specification shown in Table 3 support this observation. The ρ coefficient for the logit specification of model 4 indicates a weak positive correlation of error terms in both simultaneous regressions ($\rho = 0.145$; p-value $= 0.007$).

The adjustment for potential selection bias produced only slight changes in the WfH option coefficients for men and women, which in turn have maintained the same direction with respect to overeducation risks (e.g., a negative relationship between WfH option and overeducation). This pattern after adjusting for selection bias may indicate that unobserved common causes produced a weak bias. We then performed a likelihood ratio test in order to review whether this selection bias is different from zero or statistically negligible. The likelihood ratio tests apply the null hypothesis that the correlation ρ between error terms of the simultaneous equations equals 0 (i.e., that overeducation and WfH option do not share unobserved common causes). In the likelihood ratio test, the null hypothesis cannot be rejected at common levels of statistical significance.

Although we cannot fully rule out selection according to individual- or job-related unobserved characteristics, according to the thorough empirical strategy that we followed it seems likely that this potential selection bias is indeed small and of minor quantitative relevance. We thereby argue that these results give reasons to believe – of course with necessary caution – that selection problems are neither the only nor the main drivers of our results supporting H2.

4.2.3. The gender-overeducation gap and WfH

In H3, we assumed that especially women in cohabitation unions benefit from the WfH option to open their LLM and to avoid overeducation. Following H3, the observed gender overeducation gap in the group of employees in cohabitation unions could be significantly smaller and even closed if they have the WfH option. As mentioned earlier (see subsection 3.2), we took advantage of the possibility to consider the heterogeneity of the group with WfH option by breaking down the variable into a more detailed differentiation of WfH. Consequently, the group of employees with the WfH option were further distinguished into three groups: those deciding against the WfH option, those with WfH as work time, and those with WfH as overtime. In order to analyse whether the gender overeducation gap depends on the categories of WfH, we performed several tests.

First, in the logistic model 7 (Table 4), we considered an interaction effect between gender and WfH with the dependent variable measured in the odds metric (Buis, 2010). On the one hand, model 7 shows that the odds of having an overeducated job is 1.4 times higher for women than for men who do not have the WfH option. For men engaged in WfH during work time, the odds of having an overeducated job is 0.63 times that for men without the WfH option. On the other hand, there is also an interaction effect indicating how much the effect of WfH categories differs between men and women. The effect of WfH during work time for women is 0.89 times that for men, although this interaction is not statistically significant at conventional levels. In addition, the effect of WfH in overtime for women is 0.63 times that for men, whereas the effect of deciding against WfH for women is 0.43 times that for men. These interaction effects are in multiplicative terms, which implicitly controls for gender differences in baseline odds of overeducation.[13]

Second, acknowledging the difficulties of interpreting interaction effects in logistic regressions (Mize, 2019), we consider predicted probabilities of overeducation. The left side of Fig. 1 shows the overeducation probability for each combination of gender and WfH based on results from model 7, that is, how gender and spatial flexibility in form of WfH are jointly associated with overeducation. Indeed, WfH seems to help to close the gender overeducation gap within the group of employees in cohabitation unions. Considering the overlap of the confidence intervals (for the point estimates), the probability of overeducation for men and women seems to be different among employees without the WfH option, but not in the other employee groups. To test if those differences in the probability of overeducation are significantly different, it is necessary to additionally consider the covariance between the differences. The right side of Fig. 1 shows that the difference in the probability of overeducation between women and men is positive (higher for women) and statistically significant (at the 5-percent level) among employees without the WfH option. On the contrary, we do not observe a gender

[12] Given that the model 4 adjusts for selection into WfH option, the reduced effect of gender on overeducation is not directly interpretable with respect to the selection process or selection bias. The coefficient for gender stands for a comparison in the likelihood of women without the WfH option and men without the WfH option (which is the reference category of the dummy variable). Thus, to provide adequate interpretation of the gender coefficient with respect to selection bias, one should have modeled selection into gender rather than selection into WfH option.

[13] However, interaction effects may not only be analysed in multiplicative terms, but also through marginal effects (Buis, 2010). For the sake of completeness, we added in Appendix Table A7 the expected odds of overeducation for every combination of WfH and gender as well as the marginal effects of gender (measuring gender differences in expected odds of overeducation for every combination of WfH). Since gender is a categorical variable, we follow Buis (2010) in computing the marginal effect as a difference, so that this calculated discrete difference corresponds closely with what would actually be observed.

Table 4
Logit regression of the interaction of gender and WfH on overeducation (odds ratio [OR] and average marginal effects [AME]).

	Model 7 (Gender x WfH)	
	OR	AME
Women	1.447**	0.034*
	(0.199)	(0.016)
No WfH option	*Reference*	
WfH option:		
Decided against WfH	1.825**	0.035
	(0.366)	(0.024)
WfH work time	0.635**	−0.067***
	(0.105)	(0.014)
WfH overtime	1.026	−0.027
	(0.241)	(0.022)
Decided against WfH x women	0.430** (0.111)	*Yes*
WfH work time x women	0.894 (0.206)	*Yes*
WfH overtime x women	0.631 (0.213)	*Yes*
Controls	*Yes*	
Observations	9,549	
Log likelihood	−4,128.486	
Pseudo R-squared	0.104	

Notes: Standard errors in parentheses. Significance: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. Logit model of overeducation with standard errors clustered at small-scale official district codes (KKZ) controlling for employee age, migration, and socio-economic background (EGP I, high salariat), career aspiration, children in household, academic degree, final school grades, part-time work, leadership position, tenure (years), employment of partner, occupation (KldB, 2010, 2-digit), employer size, agglomeration type, and employment rate measured at KKZ level for the year 2015. Weighted results. Total sample includes only employees aged 20–65 and in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018, authors' calculations.

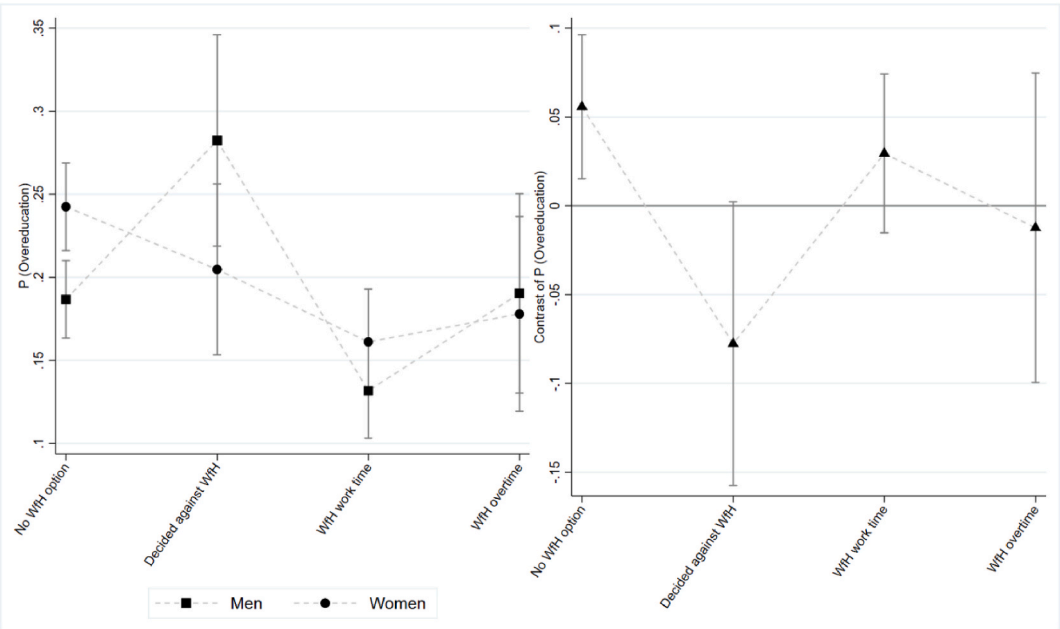

Fig. 1. Predicted probability of overeducation (AME) for each combination of gender and WfH (left side) and gender differences (women-men) of predicted probability of overeducation (right side).
Notes: Based on model 7 (interaction between gender and WfH). 95% confidence intervals. Controlled for employees' age, migration and socio-economic background (EGP I, high salariat), career aspiration, children in household, academic degree, final school grades, part-time work, leadership position, tenure (years), employment of partner, occupation (KldB, 2010, 2-digit), employer firm size, agglomeration type, and employment rate measured at KKZ level for the year 2015. Weighted results. Total sample only includes employees aged 20–65 and in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018, authors' calculations.

overeducation gap in the other employee groups, so that the probability of overeducation does not significantly differ between men and women when working from home or when deciding against it (at 5-percent levels). These results are in line with H3, considering that the most substantial gender overeducation gap is found among employees without WfH option, whereas the other groups of WfH show no statistically significant gaps.

4.3. Additional analyses[14]

Since Frank's theory of differential overqualification (Frank, 1978) refers to married couples, we re-ran the main analyses by restricting the analytic sample to married employees (80 percent of employees in cohabitation unions were legally married) to test for the more financially generous legal regulations for married couples. We expected similar patterns in the benefits of spatial flexibility for better education–job matches, given the incentive for income and career specialisation in the household through the guidelines for joint taxation of married couples (i.e., income splitting) in Germany. The results for married employees (not shown) are similar to those for employees in cohabitation unions and reinforce our argument of a gendered flexibility constraint in the labour market that hampers education–job matches.

Despite the advantage of our subjective measure of overeducation that accounts for workplace heterogeneity, we also apply an alternative objective measurement for overeducation. Although empirical evidence is hardly comparable given that the use of different overeducation measures leads to different results (Verhaest and Omey, 2010), recent studies on overeducation emphasise the benefits of applying different overeducation measures (Capsada-Munsech, 2019). To measure overeducation with a subjective indicator, we compare the educational level of employees with the formal requirement level of their job as defined in the German classification of occupations (5th digit in the KldB, 2010).[15] If the educational level of employees was higher than the formal requirement level of their job, employees were considered overeducated. The analyses with the objective measurement (not shown) show slightly different results to the subjective measurement, especially with respect to the magnitude of the gender gap in overeducation.[16] Yet, the main pattern remains: WfH option significantly reduces the overeducation risks of female and male employees.

5. Discussion and conclusion

In this study, we investigated the relationship between the gender overeducation gap of married employees and WfH in Germany. We argue that to understand differences in the incidence of overeducation between partnered men and women, it is relevant to consider the (heterogeneous) flexibility effects of WfH in the context of labour markets in the digital age. WfH as a way to overcome flexibility constraints by opening up LLM – that is, dissolving strong ties between place of residence and employer premises – should increase chances for a better education-job match. Relying on the theory of differential overqualification (Frank, 1978) and theories of mobility decisions within couples (Abraham et al., 2010; Mincer, 1978), we focused our research on partnered employees and considered differences in overeducation between partnered men and women. Especially partnered women as tied movers or tied stayers who adapt their place-of-residence choices to their husbands' workplace choices should profit from the opportunity of taking a job outside their LLM by means of WfH. We broaden the research by regarding WfH as an option for spatial flexibility in the digital age, in contrast to indicators used in previous overeducation studies in this context such as moves or commuting (e.g., Büchel and Battu, 2003). Confirming our hypotheses, our analyses resulted in three substantive conclusions.

The first conclusion is that the gender overeducation gap is evident among partnered employees, in the sense that partnered women are more likely than partnered men to be overeducated for their current jobs. This is in line with our theoretical assumptions that partnered women are spatially less flexible and thus less likely to have a job matching their educational level. The second conclusion is that the WfH option reduces risks of overeducation. This pattern is robust for potential endogenous selection bias and in line with our expectations that opening up LLMs through WfH may help individuals find jobs that correspond to their educational level. Our third conclusion is that this beneficial effect of WfH is gender-specific. Under consideration of different methodological approaches to the analysis of gender differences, we can conclude that partnered women benefit from the advantages of spatial flexibility through WfH for good education-job placements; a gender overeducation gap can only be observed among workers who do not have the WfH option. Among employees who substitute working hours traditionally spent physically at the employer's location with working hours spent at home, partnered women do not show a significantly higher rate of overeducation than partnered men.

However, our study faces several limitations. The cross-sectional structure of our data does not allow for measures of within-person job changes in order to rule out a spurious relationship between overeducation and WfH. However, due to availability of rich information in the data, we were able to control for numerous factors likely affecting overeducation and WfH feasibility, such as detailed workplace characteristics, final school grades, career motivation, and occupational dummies (see subsection 3.2). Most important, we accounted for endogenous selection into WfH options through a latent variable outcome approach using simultaneous probit and logit

[14] Results from additional analyses not shown, available on request from the authors.

[15] The fifth digit of the KldB 2010 refers to the formal requirement level of occupations and it comprises four levels to distinguish the degree of complexity of an occupation. The degree of complexity is based on the education level needed to acquire the necessary skills to perform the job (see Kracke et al., 2018; Reichelt and Vicari, 2014, for an implementation to measure overeducation).

[16] Those results should be considered as complementary rather than as a test for robustness of the main analyses. Objective and subjective indicators measure education-job mismatches at different levels (at a given aggregated occupational level or at workplace level, respectively), and so deviations and especially magnitude differences from the main analyses should be interpreted with necessary caution.

regressions. Compared to alternative fixed-effect models, which only account for time-constant unobserved characteristics, our empirical strategy adjusts for any unobserved characteristics, being time-constant or time-variant, that may be common causes of both overeducation and WfH option. We cannot completely rule out that there is endogenous sorting; however, it seems plausible that selection problems are neither the only nor the main drivers of our results.

In any case, even if the effects are not purely causal, we still believe that the patterns we observe are interesting because they show how WfH is distributed, and to what extent female and male workers are able to avoid overeducation. Moreover, due to the theoretical background, our study offers insights for the population of employees in cohabitation unions whose employment opportunities are typically more constrained by limited spatial flexibility than those of single employees. Although the findings may additionally be suggestive of trends among the population of employees, they are not representative of the total employed population (i.e., including self-employed persons).

From a policy point of view, the findings point out beneficial effects of WfH that have not yet been taken into account. Spatial flexibility increases the chances of an education–job match and, above all, helps dissolve gender differences. Even if women in particular have invested in their education in recent years and the proportion of highly skilled female workers is steadily rising (e.g., Blossfeld, et al., 2015), in many cases they are unable to fully use their qualifications on the labour market. This can partly be attributed to restrictions in spatial flexibility among partnered employees, which are mitigated by the WfH options. Working in a qualification-adequate job also affects other labour market outcomes, where female employees are still disadvantaged compared to men. In addition to better career chances, positive effects on income and thus a reduction in the gender pay gap in Germany (Lang and Groβ, 2020) could be expected if the gender overeducation gap is reduced.

Furthermore, offering WfH options can also be beneficial for employers. By encouraging workers to open their LLM through WfH, employers can recruit from a larger pool of adequately skilled workers, which is particularly recommendable in case of skill shortages.

Insights drawn from the research presented here are especially valuable since WfH recently experienced a sudden increase during the COVID-19 pandemic (Frodermann et al., 2020), during which employers invested in technical infrastructure and adapted work processes (Bellmann et al., 2020) and may also have overcome their previous concerns regarding WfH. Integrating this option of spatial flexibility, our results provide a new perspective and update the research on education–job matches. The transformed circumstances after COVID-19 provide researchers with strong incentives to expand on our new perspective and to further examining how job placements of women and men evolve with the changed regional constraints and mobility behaviours.

Appendix

Table A1, Table A2, Table A3, Table A4, Table A5, Table A6, and Table A7.

Table A1
Distribution of variables in the total sample of partnered employees and in the final analytic sample

	Total sample of employees aged 20–65 years and in cohabitation unions (n = 11,784)	Analytic sample of employees aged 20–65 years and in cohabitation unions (n = 9,549)
Overeducation		
Yes	20.04	19.63
No	79.96	80.37
WfH		
No WfH option	61.59	60.71
WfH option	38.41	39.29
devided into:		
[Decided against WfH]	[8.86]	[8.23]
[WfH work time]	[23.41]	[24.55]
[WfH overtime]	[6.14]	[6.50]
Sex		
Women	46.38	46.16
Men	53.62	53.84
Control variables		
Children		
No children	24.62	24.87
Children in household aged >6 years	23.45	23.09
Children in household aged ≤6 years	18.77	19.22
Children aged >6 years, but not in household	32.92	32.65
Children aged ≤6 years, but not in household	0.24	0.18
Partner employed		
Yes	84.19	85.12
No	15.81	14.88
Age groups		
20–34 years	21.53	22.12
35–44 years	23.46	23.46
45–54 years	32.28	31.99
≥55 years	22.73	22.43

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Table A1 (*continued*)

	Total sample of employees aged 20–65 years and in cohabitation unions (n = 11,784)	Analytic sample of employees aged 20–65 years and in cohabitation unions (n = 9,549)
Academic degree		
Yes	27.44	29.15
No	72.56	70.85
Terminal school grades		
Good to very good (grade A-B)	64.03	63.87
Satisfactory to sufficient (grade C-D)	35.97	36.13
Socio-economic background		
EGP I, high salariat	16.57	17.10
EGP II - VII	83.43	82.90
Migration background		
Yes	18.88	17.74
No	81.12	82.26
Part-time work (<20 h/week)		
Yes	6.27	5.75
No	93.73	94.25
Leadership position		
Yes	28.98	29.90
No	71.02	70.10
Continued on next page		
Career aspirations		
Yes	33.86	34.47
No	66.14	65.53
Agglomeration type (KKZ)		
City (+100.000 inhabitants)	26.18	26.48
High population-density area (+300 inhabitants/km^2)	40.12	40.03
Medium population-density area (≥150 inhabitants/km^2)	17.88	17.58
Rural area (<150 inhabitants/km2)	15.82	15.91
Employer firm size		
1–9 employees	11.62	10.84
10–49 employees	27.21	27.25
50–249 employees	26.35	26.75
250+ employees	34.82	35.17
Employment rate (log) (KKZ), mean value	6.30 (0.012)	6.31 (0.013)
Tenure (log years) (KKZ), mean value	12.87 (0.103)	12.94 (0.113)
Manual job tasks		
Yes	26.37	25.21
No	73.63	74.79
Occupation		
Armed forces personnel	0.38	0.35
Agriculture, forestry, farming	0.59	0.67
Gardening and floristry	0.73	0.55
Production and processing of raw materials, glass- and ceramic-making and -processing	0.30	0.30
Plastic-making, -processing, wood-working, -processing	1.22	1.32
Paper-making, -processing, printing, technical media design	0.70	0.63
Metal-making, -working, -construction	3.75	3.71
Technical occ. in machine-building and automotive industry	6.00	6.14
Mechatronics, energy electronics and electrical engineering	3.60	3.64
Technical research, develop., construction, production, planning and scheduling	3.33	3.58
Textile-, leather-making, and -processing	0.24	0.20
Food-production, -processing	2.45	2.28
Construction scheduling, architecture and surveying	0.86	0.92
Building construction above and below ground	1.03	1.09
Interior construction	1.38	1.22
Building services engineering, technical building services	2.19	2.09
Mathematics, biology, chemistry and physics	1.73	1.85
Geology, geography and environmental protection	0.15	0.16
Computer science, ICT	3.20	3.25
Traffic and logistics (minus vehicle driving)	5.04	4.95
	4.01	3.77

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Table A1 (*continued*)

	Total sample of employees aged 20–65 years and in cohabitation unions (n = 11,784)	Analytic sample of employees aged 20–65 years and in cohabitation unions (n = 9,549)
Drivers, operators of vehicles and transport equipment		
Safety and health protection, security, and surveillance	2.04	1.93
Cleaning services	1.68	1.44
Purchasing, sales, and trading	3.11	3.29
Retail sales	5.72	5.00
Tourism, hotels, restaurants	1.49	1.44
Business management and organization	9.28	9.56
Financial services, accounting and tax consultancy	4.32	4.74
Law and public administration	4.98	5.29
Medical and healthcare	7.33	7.29
Non-med. healthcare, body care, and med. technicians	2.60	2.40
Education and social work, housekeeping, and theology	5.61	5.56
Teaching and training	5.98	6.27
Philology, literature, humanities, social sciences, economics	0.43	0.49
Advertising, marketing, commercial, editorial media design	1.97	2.02
Product design, art craftwork, fine arts, music instruments	0.15	0.18
Performing arts and entertainment	0.42	0.43

Notes: Weighted percentages. Continuous variables with mean and standard deviations in rounded parentheses.
Source: BIBB/BAuA Employment Survey 2018. Authors' calculations.

Table A2
Odds ratio [OR] and average marginal effect [AME] of gender and WfH on opening LLM and conditional marginal effect [CME] of WfH across gender on opening LLM

	Opening LLM			
	OR	AME	CME	
Men	*Reference*	*Reference*		
Women	0.473*** (0.036)	−0.064*** (0.006)		
No WfH option	*Reference*	*Reference*	*Reference*	
WfH option:				
Decided against WfH	0.899 (0.142)	−0.008 (0.011)	for men	−0.010 (0.014)
			for women	−0.005 (0.007)
WfH, work time	1.927*** (0.151)	0.065*** (0.008)	for men	0.081*** (0.011)
			for women	0.045*** (0.006)
WfH, overtime	1.573** (0.213)	0.041** (0.014)	for men	0.052** (0.018)
			for women	0.029** (0.010)
Observations	9,069	9,069	9,069	

Notes: OR, AME, and CME base on a logit regression model of leaving LLM on WfH and gender.
Standard errors in parentheses. Significance: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Weighted results. Total sample includes only employees aged 20–65 and in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018, authors' calculations.

Table A3
Odds ratio [OR] and average marginal effect [AME] of gender and opening LLM on overeducation and conditional marginal effect [CME] of leaving LLM across gender on overeducation

	Overeducation			
	OR	AME	CME	
Men	*Reference*	*Reference*		
Women	1.161** (0.062)	0.024** (0.009)		
Not opened LLM	*Reference*	*Reference*	*Reference*	
Opened LLM	0.788* (0.238)	−0.036** (0.014),	for men	−0.034** (0.013)
			for women	−0.038** (0.014)
Observations	9,069	9,069	9,069	

Notes: OR, AME, and CME base on logit regression model of overeducation on gender and leaving LLM.
Standard errors in parentheses. Significance: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Weighted results. Total sample includes only employees aged 20–65 and in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018, authors' calculations.

Table A4
Distribution of control variables by gender.

	Men (n = 4,798)	Women (n = 4,751)	Total (n = 9,549)
Children			
No children	25.44	24.19	24.87
Children in household aged >6 years	21.85	24.54	23.09
Children in household aged ≤6 years	20.82	17.35	19.22
Children aged >6 years, but not in household	31.62	33.85	32.65
Children aged ≤6 years, but not in household	0.27	0.07	0.18
Partner employed	80.78	90.17	85.12
Age groups			
15–34 years	20.76	23.72	22.12
35–44 years	23.40	23.53	23.46
45–54 years	31.38	32.70	31.99
≥55 years	24.46	20.06	22.43
Academic degree	27.96	30.54	29.15
Terminal school grades (good to very good)	58.35	70.31	63.87
Socio-economic background (EGP I, high salariat)	16.73	17.54	17.10
Migration background	19.71	15.43	17.74
Part-time work (<20 h/week)	1.18	11.08	5.75
Leadership position	35.57	23.28	29.90
Career aspirations	38.77	29.46	34.47
Agglomeration type (KKZ)			
City (+100.000 inhabitants)	26.57	26.37	26.48
High population-density area (+300 inhabitants/km^2)	40.13	39.92	40.03
Medium population-density area (≥150 inhabitants/km^2)	17.55	17.61	17.58
Rural area (<150 inhabitants/km^2)	15.75	16.10	15.91
Employer firm size			
1–9 employees	7.48	14.76	10.84
10–49 employees	22.98	32.23	27.25
50–249 employees	27.14	26.29	26.75
250+ employees	42.41	26.72	35.17
Employment rate (log) (KKZ), mean value (*SD*)	6.3 (1.2)	6.3 (1.3)	6.3 (1.3)
Tenure (log years) (KKZ), mean value *SD*)	13.9 (11.1)	11.8 (10.9)	12.9 (11.1)
Manual job tasks	29.66	20.02	25.21

	Men (n = 4,798)	Women (n = 4,751)	Total (n = 9,549)
Occupation			
Armed forces personnel	0.49	0.19	0.35
Agriculture, forestry, farming	0.73	0.59	0.67
Gardening and floristry	0.60	0.49	0.55
Production and processing of raw materials, glass- and ceramic-making and -processing	0.44	0.15	0.30
Plastic-making, -processing, wood-working, -processing	2.12	0.40	1.32
Paper-making, -processing, printing, technical media design	0.72	0.53	0.63
Metal-making, -working, -construction	6.35	0.64	3.71
Technical occ. in machine-building and automotive industry	10.65	0.87	6.14
Mechatronics, energy electronics and electrical engineering	6.26	0.59	3.64
Technical research, develop., construction, production, planning and scheduling	5.41	1.44	3.58
Textile-, leather-making, and -processing	0.18	0.21	0.20
Food-production, -processing	2.70	1.79	2.28
Construction scheduling, architecture and surveying	1.28	0.49	0.92
Building construction above and below ground	1.98	0.05	1.09
Interior construction	2.17	0.10	1.22
Building services engineering, technical building services	3.77	0.12	2.09
Mathematics, biology, chemistry and physics	2.33	1.29	1.85
Geology, geography and environmental protection	0.12	0.22	0.16

	Men (n = 4,798)	Women (n = 4,751)	Total (n = 9,549)
Computer science, ICT	4.99	1.22	3.25
Traffic and logistics (minus vehicle driving)	6.37	3.29	4.95
Drivers, operators of vehicles and transport equipment	6.77	0.29	3.77
Safety and health protection, security, and surveillance	3.10	0.56	1.93
Cleaning services	0.62	2.39	1.44
Purchasing, sales, and trading	4.03	2.43	3.29
Retail sales	1.81	8.73	5.00
Tourism, hotels, restaurants	0.67	2.34	1.44
Business management and organization	5.83	13.91	9.56
Financial services, accounting and tax consultancy	2.60	7.23	4.74
Law and public administration	3.05	7.90	5.29
Medical and healthcare	2.10	13.34	7.29
Non-medical healthcare, body care, wellness and medical technicians	0.94	4.10	2.40

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Table A4 (*continued*)

	Men (n = 4,798)	Women (n = 4,751)	Total (n = 9,549)
Education and social work, housekeeping, and theology	1.67	10.10	5.56
Teaching and training	4.69	8.11	6.27
Philology, literature, humanities, social sciences, economics	0.27	0.76	0.49
Advertising, marketing, commercial, editorial media design	1.44	2.71	2.02
Product design, artisan craftwork, fine arts, making of musical instruments	0.16	0.21	0.18
Performing arts and entertainment	0.61	0.21	0.43

Notes: Weighted percentages. Continuous variables with mean and standard deviations in parentheses. Total sample includes only employees aged 20–65 and in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018. Authors' calculations.

Table A5
Distribution of all variables by WfH categories (percent).

	No WfH option (n = 4,871)	Decided against WfH (n = 833)	WfH work time (n = 3,094)	WfH overtime (n = 751)	Total (n = 9,549)
Overeducated	21.61	25.05	13.43	17.68	19.63
Children					
No children	24.33	20.80	26.01	30.72	24.87
Children in household aged >6	22.10	28.53	24.97	18.31	23.09
Children in household aged ≤6 years	18.23	14.86	22.93	19.98	19.22
Children aged >6, but not in household	35.20	35.81	25.76	30.82	32.65
Children aged ≤6, but not in household	0.14	0.00	0.33	0.17	0.18
Partner employed	84.00	82.51	88.51	86.02	85.12
Age groups					
15–34 years	22.68	18.63	22.01	21.81	22.12
35–44 years	22.47	21.90	25.48	27.09	23.46
45–54 years	31.53	36.67	32.55	28.17	31.99
≤55 years	23.32	22.80	19.96	22.92	22.43
Academic degree	15.09	26.22	59.13	50.98	29.15
Terminal school grades (good to very good)	58.72	68.85	73.18	70.57	63.87
Socio-economic background (EGP I, high salariat)	13.54	16.36	25.25	20.52	17.10
Migration background	17.83	20.12	16.57	18.21	17.74
Part-time work (<20 h/week)	6.03	9.12	4.51	3.56	5.75
Leadership position	26.44	26.45	35.30	46.08	29.90
Carrier aspirations	31.97	26.79	40.68	44.08	34.47
Agglomeration type (KKZ)					
City (≥100.000 inhabitants)	22.83	26.88	33.65	32.97	26.48
High population-density area (≥300 inhabitants/km^2)	39.78	39.41	41.73	36.76	40.03
Medium population-density area (≥150 inhabitants/km^2)	19.41	17.92	13.67	14.84	17.58
Rural area (<150 inhabitants/km^2)	17.98	15.79	10.96	15.43	15.91
Employer firm size					
1–9 employees	11.37	9.06	10.45	9.57	10.84
10–49 employees	29.23	26.09	23.11	25.84	27.25
50–249 employees	26.39	26.27	27.63	27.36	26.75
250+ employees	33.01	38.58	38.80	37.24	35.17
Employment rate (log) (KKZ)	6.17 (1.15)	6.37 (1.34)	6.59 (1.51)	6.47 (1.47)	6.31 (1.29)
Tenure (log years) (KKZ)	12.98 (10.38)	13.98 (11.77)	12.46 (12.01)	13.12 (12.03)	12.94 (11.11)
Manual job tasks	34.97	19.61	6.51	11.79	25.21
Occupation	21.61	25.05	13.43	17.68	19.63
Armed forces personnel	0.37	0.82	0.15	0.34	0.35
Agriculture, forestry, farming	0.67	0.99	0.67	0.14	0.67
Gardening and floristry	0.68	0.53	0.30	0.28	0.55
Production and processing of raw materials, glass- and ceramic-making and -processing	0.49	0.00	0.02	0.00	0.30
Plastic-making, -processing, wood-working, -processing	1.63	2.61	0.35	0.44	1.32
Paper-making, -processing, printing, technical media design	0.74	0.88	0.34	0.40	0.63
Metal-making, -working, -construction	5.78	0.92	0.38	0.56	3.71
Technical occupations in machine-building and automotive industry	7.76	5.77	2.93	3.57	6.14
Mechatronics, energy electronics and electrical engineering	3.74	2.99	3.67	3.51	3.64
Technical research, develop., construction, production, planning and scheduling	3.33	4.12	3.45	5.66	3.58

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Table A5 (*continued*)

	No WfH option (n = 4,871)	Decided against WfH (n = 833)	WfH work time (n = 3,094)	WfH overtime (n = 751)	Total (n = 9,549)
Textile-, leather-making, and -processing	0.26	0.16	0.09	0.00	0.20
Food-production, -processing	2.85	2.27	0.55	3.45	2.28
Construction scheduling, architecture and surveying	0.76	0.95	1.32	0.80	0.92
Building construction above and below ground	1.56	0.69	0.17	0.70	1.09
Interior construction	1.77	0.31	0.41	0.19	1.22
Building services engineering, technical building services	2.89	0.24	0.67	2.30	2.09
Mathematics, biology, chemistry, and physics	2.20	1.34	1.00	2.37	1.85
Geology, geography and environmental protection	0.10	0.12	0.16	0.84	0.16
Computer science, ICT	0.84	2.74	9.90	1.32	3.25
Traffic and logistics (without vehicle driving)	6.33	4.74	2.13	2.91	4.95
Drivers, operators of vehicles and transport equipment	5.71	1.69	0.62	0.25	3.77
Safety and health protection, security and surveillance	2.46	1.02	0.95	1.81	1.93
Cleaning services	1.81	2.32	0.40	0.84	1.44
Purchasing, sales and trading	1.95	2.27	6.13	6.35	3.29
Retail sales	6.88	4.07	1.08	3.41	5.00
Tourism, hotels, restaurants	1.56	1.50	0.93	2.26	1.44
Business management and organization	6.40	14.04	15.55	10.82	9.56
Financial services, accounting, and tax consultancy	3.73	8.89	6.10	3.75	4.74
Law and public administration	4.50	10.61	5.32	5.81	5.29
Medical and healthcare	9.06	7.95	3.23	5.20	7.29
Non-medical healthcare, body care, wellness, and medical technicians	2.92	2.61	0.94	2.74	2.40
Education and social work, housekeeping, and theology	5.01	6.43	6.07	7.68	5.56
Teaching and training	1.30	1.38	18.06	14.30	6.27
Philology, literature, humanities, social sciences, economics	0.21	0.12	1.22	0.91	0.49
	No WfH option (n = 4,871)	Decided against WfH (n = 833)	WfH work time (n = 3,094)	WfH overtime (n = 751)	Total (n = 9,549)
Advertising, marketing, commercial, editorial media design	1.26	1.73	3.73	3.05	2.02
Product design, artisan craftwork, fine arts, making of musical instruments	0.18	0.10	0.06	0.80	0.18
Performing arts and entertainment	0.29	0.07	0.94	0.23	0.43

Notes: Weighted percentages. Continuous variables with mean and standard deviations in parentheses. Total sample includes only employees aged 20–65 and in cohabitation unions .
Source: BIBB/BAuA Employment Survey 2018. Authors' calculations.

Table A6
Distribution of overeducation and WfH by gender (percent, only employees not in cohabitation unions)

	Men (n = 2,100)	Women (n = 2,323)	Total (n = 4,423)
Overeducation	20.3	22.2	21.2
WfH			
No WfH option	68.0	62.5**	65.5
WfH option	32.0	37.5**	34.5
devided into:			
[Decided against WfH]	[8.5]	[10.9]	[9.6]
[WfH work time]	[18.4]	[20.5]	[19.4]
[WfH overtime]	[5.1]	[6.1]	[5.6]

Notes: Weighted percentages. Mean differences statistically significant with $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. Total sample includes only employees aged 20–65 and *not* in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018. Authors' calculations.

Table A7
Odds of overeducation for every gender and WfH combination (based on logit regression of model 7 with interaction between gender and WfH)

	Ratio of odds ratio	Difference (marginal effect)
Men, no WfH option	0.278*** (0.022)	
Women, no WfH option	0.406*** (0.032)	
Difference (women – men)		0.128*** (0.038)
Men, decided against WfH	0.508*** (0.092)	

(*continued on next page*)

Table A7 (*continued*)

	Ratio of odds ratio	Difference (marginal effect)
Women, decided against WfH	0.321*** (0.058)	
Difference (women – men)		−0.186 (0.106)
Men, WfH work time	0.164*** (0.020)	
Women, WfH work time	0.178*** (0.020)	
Difference (women – men)		0.013 (0.031)
Men, WfH overtime	0.246*** (0.053)	
Women, WfH overtime	0.246*** (0.055)	
Difference (women – men)		−0.000 (0.078)
Observations	9,549	
Log likelihood	−4,128.4865	

Notes: Standard errors in parentheses. Significance: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. Logistic model of overeducation for employees in cohabitation unions with standard errors clustered at small-scale official district codes (KKZ) controlling for employees' age, migration, and socio-economic background (EGP I, high salariat), career aspiration, children in household, academic degree, terminal school grades, part-time work, leadership position, tenure (years), employment of partner, occupation (KldB, 2010, 2-digit), employer firm size, agglomeration type, and employment rate measured at KKZ level for the year 2015. Weighted results. Total sample only includes employees aged 20–65 and in cohabitation unions.
Source: BIBB/BAuA Employment Survey 2018, authors' calculations.

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