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Taylor & Francis Group

Population Studies
A Journal of Demography

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rpst20

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To cite this article: Honorata Bogusz, Anna Matysiak & Michaela Kreyenfeld (13 Aug 2024): Structural labour market change, cognitive work, and entry to parenthood in Germany, Population Studies, DOI: 10.1080/00324728.2024.2372018

To link to this article: https://doi.org/10.1080/00324728.2024.2372018

Published online: 13 Aug 2024.

Population Studies, 2024
https://doi.org/10.1080/00324728.2024.2372018

Structural labour market change, cognitive work, and entry to parenthood in Germany

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Technological change and globalization have caused unprecedented transformations of labour markets, resulting in a growing division between workers who perform cognitive vs non-cognitive tasks. To date, only few studies have addressed the fertility effects of these long-term structural changes. This study fills that gap. We measure the cognitive task content of occupations using data from the Employment Survey of the German Federal Institute for Vocational Education and Training, which we link to individual histories from the German Socio-Economic Panel 1984–2018. We find that women and men with non-cognitive jobs are increasingly less likely to enter parenthood; this is reflected in lower first-birth intensities but also in higher probabilities of childlessness compared with workers in highly cognitive jobs. These findings imply that structural shifts in the labour market are exacerbating disparities between low-skilled and highly skilled individuals, not only within the labour market but also in the realm of family formation.

Keywords: structural labour market change; cognitive work; task content of work; fertility; Germany

[Submitted April 2023; Final version accepted February 2024]

Introduction

Over the last three decades, technological change and globalization have led to substantial transformations of labour markets in advanced economies (World Bank 2019). These structural labour market changes have also created new divisions in the sphere of work, resulting in growing inequalities in earnings, job stability, job flexibility, and career opportunities among workers. The new demarcation line seems to run between workers who perform mainly cognitive tasks and those who perform mainly non-cognitive tasks. The labour demand for the former has been on the rise, as cognitive skills —either analytic or social/interpersonal—are increasingly sought after in the rapidly expanding high-tech sectors and in specialized consumer service, business, and education (Acemoglu and Autor 2011; Cortes et al. 2023). As a result of the development of information and communication technologies, cognitive workers increasingly enjoy higher flexibility in where and when they work, although often at the price of greater responsibility for their work outcomes (Van Echtelt et al. 2009; Kvande 2017). At the same time, the demand for workers who perform non-cognitive tasks, in particular routine manual tasks, has been on the decline, as these sorts of tasks can be easily automated or offshored to countries with lower labour costs (Acemoglu and Autor 2011; World Bank 2019).

These developments may not only increase labour market disparities between more highly skilled and lower-skilled workers but may also affect family behaviour, including the decision whether and when to become a parent. There has been broad consensus among demographers that earnings prospects (Oppenheimer 1997; Hart 2015), job stability (Adsera 2011; Hofmann et al. 2017; Alderotti et al. 2021), and the compatibility of paid work with family life (Begall et al. 2015; Wood et al. 2020; Osiewalska et al. 2024) are important determinants of family formation. Growing demand for highly

skilled workers and increasing flexibility of work schedules provide cognitive workers with better opportunities for earning income and combining paid work with family life, thereby improving their conditions for having children. The same structural developments in the labour market, however, worsen low-skilled workers' conditions for having children by making certain non-cognitive job tasks and occupations redundant (Arntz et al. 2016; Nedelkoska and Quintini 2018) and by depriving these workers of employee-oriented flexibility (Chung 2018). As structural changes in the labour market are permanent in nature (in contrast to economic recessions, which are cyclical and temporary), they may lead to long-term changes and divergences in the fertility behaviour of workers in occupations requiring non-cognitive vs cognitive tasks. It is thus imperative to understand how these labour market changes affect childbearing, not only for explaining past trends in fertility but also to provide insights about its future developments.

In this study, we take a first step in that direction. In particular, we examine how long-term structural changes in the labour market are associated with the process of entering parenthood and whether they lead to different patterns of first births between workers with jobs that are in high demand on the labour market, as opposed to those in jobs exposed to automation or offshoring. To date, this question has not been addressed. Past demographic research has provided rich evidence on how unemployment, income, type of work contract, and subjective measures of employment and financial uncertainty relate to birth behaviour, including entry to parenthood (Kreyenfeld 2010; Adsera 2011; Vignoli et al. 2012; Alderotti et al. 2021). Further, scholars have examined how the process of becoming a parent is influenced by non-standard or flexible work schedules or the opportunity to work from home (Begall et al. 2015; Matysiak and Mynarska 2020; Osiewalska et al. 2024). By drawing on established measures of employment and economic vulnerability, these studies have shown how economic uncertainty and difficulties with combining paid work and care affect the transition to parenthood and that patterns differ by context and sex. In this study, we add to those findings by examining how first-birth behaviour is related to the digitalization- and globalization-induced changes in labour markets.

To capture the recent structural changes in the labour market, we follow the *task-based approach*, which has recently been adopted in labour market economics (e.g. Autor et al. 2003; Arntz et al. 2016; De La Rica et al. 2020). This approach presupposes that jobs consist of a variety of tasks that require certain skills. Since technology and globalization change the structure of tasks—with some tasks being taken over by machines and others being offshored—they modify the demand for skills and thus affect workers' labour market prospects. In contrast to occupations with low cognitive task content, those with high cognitive task intensity offer better long-term labour market opportunities for earning income and flexible organization of the workplace and working time, although sometimes at the price of blurred boundaries between paid work and family life and also high work intensity (Van Echtelt et al. 2009; Kvande 2017).

The great benefit of the task-based approach is that it not only describes the relationship between the task content of work and labour market change but it also offers a toolkit for measuring the task intensity of work by relying on occupational codes. We measure the task content of occupations using data from the Employment Survey run by the German Federal Institute for Vocational Education and Training (see Bundesinstitut für Berufsbildung (BIBB), Berlin, and Institut für Arbeitsmarkt- und Berufsforschung (IAB) der Bundesanstalt für Arbeit, Nürnberg 1983, 1995, 2016; Jansen and Dostal 2015; Hall et al. 2020a, 2020b; Hall and Tiemann 2021). These data allow us to generate measures of cognitive task intensity (both analytic and interactive) at the three-digit occupation level. We then link these contextual occupation-specific data to micro-level data from the German Socio-Economic Panel (GSOEP; Goebel et al. 2019) for the years 1984–2018. We use event-history models to model transition to parenthood, with task content as the main time-varying variable. For easier interpretation of the results, we estimate predicted cumulative first-birth probabilities for certain 'ideal types' of workers. Because the GSOEP data (Release 37) provide us with information from 1984 to 2018, this gives us the opportunity to examine a 35-year period that encompasses both the early and advanced stages of digitalization- and globalization-driven labour market change, allowing us to examine how structural labour market changes have been associated with first-birth patterns over time.

Background

Changing demand for job tasks and rising work autonomy

Globalization and the adoption of new technologies have led to tremendous changes in the structure of

tasks demanded in the labour market (Autor et al. 2003; Acemoglu and Autor 2011). It has been widely demonstrated that workers who can perform abstract tasks (also called non-routine cognitive tasks) are in the greatest demand (Autor et al. 2006; World Bank 2019; Cortes et al. 2023). Abstract tasks require creativity, problem-solving, and complex organization and communication, and they are not easy to automate or offshore. These tasks can be *analytic* (i.e. demanding the ability to process, analyse, and interpret data when making a decision) or *social/interpersonal* (i.e. requiring the ability to engage in interactions with people, teamwork, negotiations, conflict resolution, etc.). Apart from abstract tasks, workers may also carry out non-cognitive routine tasks (which are repetitive and involve following easily programmable rules) and non-cognitive manual tasks (which require motor skills or physical strength).

Workers who are able to perform abstract tasks are increasingly likely to find and maintain employment (Autor et al. 2006; Deming 2017) and to experience upward occupational mobility (Fedorets 2019) and increases in pay (Borghans et al. 2014; Deming 2017). At the same time, the labour market opportunities for workers whose skill levels do not enable them to perform abstract tasks have been deteriorating sharply (Hardy et al. 2018; World Bank 2019). These processes have resulted in growing inequalities between workers in cognitive and non-cognitive jobs in terms of their earnings (Bacolod and Blum 2010; Borghans et al. 2014; Baumgarten et al. 2020), their occupational prestige and job satisfaction (Oesch and Piccitto 2019), and the precarity of their contract type (Peugny 2019), across many developed countries.

Workers who can perform abstract tasks have not only benefited from the increased demand for their skills but have also been granted greater work autonomy. Closely related to the rise of information and communication technologies, opportunities to work flexible hours or engage in home-based teleworking have increased rapidly in recent years (Rubery 2015; Arntz et al. 2022), mostly benefiting workers with cognitive skills, for example managers and professionals (Chung 2018). As this flexibility can make it easier for workers to adjust their work hours to the needs of their family, it has the potential to facilitate work–life balance (Demerouti et al. 2014). However, empirical research has also pointed out some potential negative consequences of work schedule and workplace location flexibility —such as longer working hours (Felstead and Henseke 2017; Kvande 2017), round-the-clock availability (Presser 2003), more fragmented working time, and blurred boundaries between paid work and family life (Lott and Abendroth 2023)—all of which can ultimately lead to intensification of work–family conflict.

These changes in the labour market have affected both women and men. However, women have moved from non-cognitive to cognitive jobs more quickly than men (Bacolod and Blum 2010; Black and Spitz-Oener 2010). Whereas, in the past, jobs that involved routine/repetitive tasks were taken mainly by women, this pattern is currently observed only among earlier birth cohorts (Brussevich et al. 2019). Meanwhile, low-skilled jobs that involve manual tasks continue to be taken mainly by men (Yamaguchi 2018; Brussevich et al. 2019). At the same time, men are more likely than women to work in highly skilled occupations that involve performing intensive analytic tasks or social/interpersonal tasks that require managerial skills (Liu and Grusky 2013; Matysiak et al. 2024). These kinds of jobs usually give workers high autonomy in how, where, and when work is carried out (Golden 2008; Cukrowska-Torzewska et al. 2023). By contrast, in most European countries, women are over-represented in occupations that involve social/interpersonal tasks oriented towards providing interactive services to others (e.g. healthcare, teaching, nursing), and these occupations are often associated with lower wage returns (England 2005; Liu and Grusky 2013; Matysiak et al. 2024) and less flexibility (Golden 2008; Cukrowska-Torzewska et al. 2023).

Structural labour market changes and parenthood

The structural labour market transformations will likely have had serious implications for fertility behaviour, including transition to first child, as they have greatly altered the conditions for earning income and combining paid work with childcare, conditions that have been shown to be important determinants of family formation (Hofmann et al. 2017; Greulich et al. 2018; Marynissen et al. 2020; Alderotti et al. 2021). Scholars have posited that patterns are gendered and context specific. In (modernized) male breadwinner societies such as Germany, men's earnings and their stable employment are crucial for entering parenthood (Kreyenfeld et al. 2012; Andersson et al. 2014). In line with this argument, empirical research has shown that couples in which the male partner is employed and has high earnings are more likely to transition to first birth,

whereas couples in which the male partner is unemployed or has a time-limited working contract are more likely to postpone parenthood until the uncertainty around the man's labour market position is resolved (Kreyenfeld et al. 2012). It is thus highly likely that structural labour market changes have created better conditions for parenthood for men employed in cognitive jobs, by improving their earning opportunities. At the same time, they have led to a worsening of employment and earning conditions for non-cognitive workers, thereby lowering their chances of family formation.

The impact of women's economic activity on transition to first birth is more ambiguous. Conventional theoretical approaches have argued that due to the combination of gendered care patterns and incompatibility of employment with care obligations, having children is associated with high opportunity costs for women. Therefore, women who are on a promising career track are likely to postpone the transition to motherhood or remain childless altogether (e.g. Gustafsson 2001). More recent theoretical approaches have challenged this view, however, pointing to the expansion of policies that facilitate work–family reconciliation by increasing access to childcare and income-related parental leave, the spread of more egalitarian gender role attitudes, and greater involvement by men in childcare and housework (McDonald 2000; Esping-Andersen and Billari 2015; Goldscheider et al. 2015).

Structural labour market changes may further erode the role of the traditional family model for childbearing in future. Growing economic uncertainties create a need for both partners to participate in the labour market to diversify the risks of a job loss for the household income. At the same time, the increasing flexibility to choose when and where to work may improve the reconciliation of paid work and childcare, making it easier for working women to have children than in the past. However, this increase in work autonomy does not affect all women but rather those in cognitive jobs and, more often, jobs involving analytic work. Structural labour market changes may thus improve the conditions for having children for women in cognitive jobs but not necessarily for women in non-cognitive jobs, for which the increasing pressure to work for pay is not accompanied by higher flexibility in work schedules and work location. In other words, structural labour market changes may improve the conditions for becoming a mother among women in cognitive occupations but not for women in non-cognitive jobs.

Country context

This study is conducted on Germany. Germany's labour market is known for its heavy demand for highly skilled labour (Spitz-Oener 2006; Rohrbach-Schmidt and Tiemann 2013). The transformation of Germany's economy into a knowledge economy began in the late 1960s. Germany maintained its manufacturing traditions but invested strongly in modernization and digitalization of manufacturing (Thelen 2019). Like other countries, it also experienced a substantial increase in occupational complexity, with abstract job tasks, both analytic and social/interpersonal in nature, becoming increasingly important (Spitz-Oener 2006). These changes took place within all occupational and occupation-educational groups (Spitz-Oener 2006) and occurred more quickly among women (who frequently moved out of jobs that became automated) than among men (Black and Spitz-Oener 2010).

The structure of the labour market makes Germany an ideal test case for examining the consequences of digital transformation on family behaviour. It is also ideal for showcasing the role of sex differences in this transformation due to its strongly gendered care patterns. Germany used to be classified as a conservative welfare state model (Esping-Andersen 1990; Amable 2003) that was based on strong employment protections and coordinated bargaining systems (Amable 2003). The sole breadwinner model was supported by the tax and transfer system, and the limited availability of full-time day care inhibited mothers' labour market integration. In 2007, a parental leave reform was enacted, introducing an income-related parental leave that reserved two months of leave for each parent (often referred to as the 'paternity quota'; Henninger et al. 2008). Furthermore, full-time day care has been systematically expanded since 2005, and in 2013 a legal right to a day-care slot was introduced for all children aged one year and older. The large majority of couple households with children are organized as dual-worker households. In 2019, for example, 65 per cent of couple households with children were dual-earner households, only 29 per cent were single-earner households, and in 6 per cent of cases neither of the partners worked (BMFSFJ 2023). While large fractions of mothers work, most work only part-time (Boll and Lagemann 2019; Müller and Wrohlich 2020), especially in West Germany (Stahl and Schober 2018).

With respect to birth patterns, West Germany has experienced a steady postponement of first

childbirth in recent decades. While age at first childbearing was around age 24 in the 1960s (Kreyenfeld 2002), it had increased to around age 30 by 2020 (DESTATIS 2023). Cohort fertility rates used to be the lowest and childlessness among the highest of all European countries (Sobotka 2017). For example, cohort fertility declined from 1.72 for women born in 1950 to only 1.56 for those born in 1965 (Human Fertility Database 2023). Further, birth patterns differed radically by women's education. For the 1950s cohorts, around 20 per cent of (West) German women remained childless overall, whereas among university-educated women ultimate childlessness was around 30 per cent (Kreyenfeld and Konietzka 2017, p. 30). In more recent years, educational differences in childlessness among women have narrowed (Kreyenfeld and Konietzka 2017, p. 105). At the same time the association between employment characteristics and fertility has become less gendered than in the past. Thus, not only men's but also women's unemployment and low wages have been reducing first-birth rates (Lambert and Kreyenfeld 2023). Important to note is that East–West differences in fertility behaviour have largely converged since unification, but some small differences in ages at first birth have persisted, however (e.g. Goldstein and Kreyenfeld 2011).

Hypotheses

Given that women's and men's labour market opportunities affect the process of becoming a parent, it is likely that these ongoing structural labour market changes will be manifested in first-birth patterns. Thus, a first guiding hypothesis is that work with a low cognitive task intensity will be reducing first-birth probabilities relative to work with a medium or high cognitive task intensity (*Hypothesis 1a*). We also anticipate that the structural changes in the labour market will be increasing employment, earnings, and flexible work opportunities disproportionally strongly for workers in jobs with high cognitive task intensity. As a result, first-birth patterns should be increasingly diverging over time between workers in occupations characterized by low and high cognitive task intensity (*Hypothesis 1b*).

Fertility and employment patterns may have been gendered in the past, but as women's participation in the labour market and men's participation in childcare have increased, we expect that the transition to parenthood will be becoming more similar for men and women over time (*Hypothesis 2a*). We may assume that this convergence applies to both analytic and interactive cognitive occupations, although some sex differences may emerge for occupations which require high interactive task content. As mentioned earlier, occupations with high interactive task content requiring managerial skills are more often chosen by men, while women more often choose interactive occupations that involve providing services to others (e.g. healthcare, teaching, nursing) (Liu and Grusky 2013; Matysiak et al. 2024). The former occupations are usually better paid and provide more flexibility. We thus expect the convergence among women and men in transition to first birth to be stronger for analytic than for interactive tasks (*Hypothesis 2b*).

Data and measures

Data sources

In our study we make use of two data sources. The main data set is the GSOEP (Release 37), which we use to model the relationship between men's and women's occupational histories and first-birth transitions. The GSOEP is longitudinal panel survey, ongoing since 1984. These data are well suited to our investigation as the survey collects complete fertility histories from both men and women and includes three-digit occupational codes for the employed (Goebel et al. 2019). It is worth noting that several subsamples have been included in the GSOEP across time (e.g. a sample that included the East German population in 1990 and several migration and refreshment samples).

We limit our sample to childless individuals of childbearing age (20–49). We do not include respondents below age 20, because these individuals are predominantly in education; thus, their current labour market situation is unlikely to be a determinant of their fertility. We also limit the sample to individuals with German citizenship and to respondents who provided valid information in the birth biographies (around 2 per cent had missing information). We include all data for the years 1984–2018, but as we lag the main covariates by two years, we observe fertility in the period 1986–2018. By doing so, we cover a large part of the period when Germany was undergoing the transition to becoming a knowledge economy, including the structural labour market changes caused by globalization and digitalization (Thelen 2019; Dauth et al. 2021). It should, however, be noted that East Germany is included only from 1990. Finally, very specialized subsamples, such as the refugee sample, the high-

income sample, and the LGBTQ+ sample are excluded from the analysis. We organize our data in long format, with each survey year contributing one entry to our sample. Thus, individuals are right-censored when they drop out of the survey or when they reach age 49. They are left-truncated if they enter the survey at over 20 years old. The total number of person-years in the sample is 101,440, and the number of events (first births) is 3,989.

To construct the task measures at the occupational level, we use the BIBB Employment Survey. These measures are next linked to our analytical sample from the GSOEP via the three-digit occupation codes included in the employment biographies. The BIBB Employment Survey is a repeated cross-sectional survey that has been conducted every six to seven years since 1979, with seven waves so far (1979, 1986, 1992, 1999, 2006, 2012, and 2018). It contains detailed information on job characteristics, such as tasks performed at work (e.g. programming, cleaning, teaching), work location, work schedules, working hours, contract types, and wages. These data allow us to identify which occupations involve mainly abstract tasks and to differentiate between analytic and interactive task content. Using the three-digit occupational codes, this information is merged with the GSOEP data.

Independent variables

We assess the cognitive content of occupations using two measures that distinguish between *analytic* and *social/interpersonal* task content. By doing so, we build on the framework for quantitatively assessing the task content of work that was first proposed by Autor et al. (2003) and adapted to the German context by Spitz-Oener (2006) and Rohrbach-Schmidt and Tiemann (2013). We classify tasks as 'analytic' or 'interactive' following the criterion validation method suggested in Rohrbach-Schmidt and Tiemann (2013). The analytic domain quantifies activities that are non-manual and non-routine (e.g. programming, researching), while the interactive domain quantifies non-repetitive tasks that require human interaction (e.g. consulting, managing). The exact task items that we measure and their availability in consecutive waves are displayed in Table 1.

We derive the measures of the cognitive content of occupations using the BIBB Employment Survey data. Unfortunately, the samples are not comparable across consecutive waves unless they are restricted. Thus, following the recommendation of Rohrbach-Schmidt and Tiemann (2013), we restrict the data to balance the samples. This includes keeping records only for employed individuals who were from West Germany, had German citizenship, were aged 15–64 (active workforce), and were working between 10 and 168 hours a month. Using these data, we apply the following formulas:

$$j\,\text{task measure}_{ot} = \frac{\sum_{i=1}^{N} j\,\text{task measure}_{oit}}{N} \tag{1}$$

where:

$$j\,\text{task measure}_{oit} = \frac{\text{number of items in category } j \text{ performed by } i \text{ in time } t}{\text{total number of items in category } j \text{ in time } t} \tag{2}$$

and o = occupation, i = individual, $j \in$ {analytic, interactive}, and $t \in$ {1979, 1986, 1992, 1999, 2006, 2012, 2018}. Equation (2) corresponds to the measure first developed in Spitz-Oener (2006) and applied in (among others) Black and Spitz-Oener (2010) and Rohrbach-Schmidt and Tiemann (2013). Its values range from zero to 100, and it quantifies the degree to which an individual's work requires them to apply analytic or interactive skills. For example, suppose that a worker performs four tasks classified as analytic out of the five analytic task items considered (see Table 1). Then, their analytic task measure is $(4/5) \times 100 = 80$. We average Equation (2) over individuals to obtain Equation (1): a measure at occupation level that can then be merged with individual data from the GSOEP by three-digit occupational code. We interpret this as reflecting the extent to which an occupation has high analytic or interactive task intensity. Since we have measures for seven points in time, we use a simple linear interpolation to obtain observations between the available time points.

The continuous task measures are transferred into the following five categories: low [0, 33), medium [33, 66), high [66, 100], in education, and the residual category (inactive, unemployed, occupation missing). We do not use them as continuous variables, to account for individuals without valid task measures in the sample. Individuals who were not

Table 1 Availability and classification of the task items in the BIBB Employment Survey, Germany

Number	*Task item*	*Waves available*	*Task category*
1	Investigating	1999, 2006, 2012, 2018	Analytic
2	Organizing	All	Analytic
3	Researching	All except 1999	Analytic
4	Programming	All except 1999	Analytic
5	Applying law	1979, 1986, 1992	Analytic
6	Teaching	All	Interactive
7	Consulting	All	Interactive
8	Buying	All	Interactive
9	Promoting	All except 1986	Interactive
10	Managing	1979, 1986, 1992	Interactive
11	Negotiating	1979, 1999	Interactive

Note: Waves to date were conducted in 1979, 1986, 1992, 1999, 2006, 2012, and 2018.
Source: BIBB Employment Survey; Rohrbach-Schmidt and Tiemann (2013).

working (inactive, unemployed, in education) have no valid occupational codes.

Besides the respondent's age, we control for the following individual characteristics: region of residence (West/East Germany), number of siblings (zero, one, two or more), and calendar period. Task measures and residence are time-varying and lagged by two years to account for the duration of pregnancy (one year in year-based analysis) and the fact that an individual might take some time to decide whether to have children, given their labour market situation.

Method and analytical strategy

This analysis is conducted separately for women and men. With annual data at our disposal, we model the transition to first birth using hazard models with a complementary log–log function of form:

$$\log\left[-\log\left(1-\lambda\right)\right] = \beta' x \tag{3}$$

where the fitted probability $\hat{\lambda}$ can be expressed:

$$\hat{\lambda} = 1 - \exp[-\exp(\beta' x)] \tag{4}$$

The function from Equation (3) is sometimes referred to as a 'gompit' model, due to its relationship to the Gompertz distribution (Box-Steffensmeier and Jones 2004). As the function from Equation (3) is asymmetric, it is suitable for survival analysis based on data with relatively few failures. For this reason, the gompit model has been relatively popular in fertility research (Gerster et al. 2007). We include duration in a piecewise constant hazard fashion. The process time t is the respondent's biological age divided into five intervals: 20–24, 25–29, 30–34, 35–39, and 40–49.

The models just specified allow for an assessment of the general relationship between the cognitive content of women's and men's work and their entry to parenthood (Model 1). We are, however, also interested in investigating how these relationships have changed over time. To this end, we interact individuals' task measures with time period (Model 2).

We suspect that before individuals can enter occupations that require cognitive skills, they often have to complete lengthy periods of education. Thus, labour market entry may occur later in life for individuals working in occupations that require cognitive labour. If individuals enter the labour market when they are older, they may have reached a point in their life course that would lead them to accelerate childbearing (Impicciatore and Tomatis 2020). This aspect is relevant for us, as our event-history model relies on the proportionality assumption, which requires the covariates to have the same effect at all durations. An acceleration of childbirth after labour market entry is not 'built in' to this model. Thus, the results may be biased if the proportional hazard assumption is not relaxed. To test for this possibility, we interact individuals' task measures with age (Model 3). This model is first estimated on the full sample, covering the years 1984–2018. However, to be able to trace changes in the relationship between task content of occupations and first-birth probabilities over time and to account for differences in birth timing across different task categories, we also estimate Model 3 on two subsamples, for the periods 1984–99 and 2000–18 (Models 4a–b). While the findings from Models 1–3 are displayed as average predicted probabilities, we use the estimates from Models 4a–b to generate cumulative incidence curves for

some specific covariate constellations. Cumulative incidence curves are presented to better understand and illustrate the differences in the timing and probability of having a first child between workers with high and low cognitive task intensity. The cumulative incidence curves require us to select specific covariate constellations. We compute cumulative incidence for three cases (ideal types):

- Case 1: A person who enters the labour market before age 20 and works in an occupation characterized by low task intensity.
- Case 2: A person who finishes education at age 24 and then works in an occupation characterized by medium task intensity.
- Case 3: A person who stays in education until age 29 and then works in an occupation characterized by high task intensity.

We choose these cases based on descriptive analysis of lifetime employment patterns, where we plot mean analytic and interactive task measures (respectively) across age by highest task measure ever achieved at age 35+ (Appendix Figure A1).

Results

Cognitive work: Descriptive results

Before discussing our findings on cognitive task intensity and birth transitions, we present some descriptive information on our measures of the task content of work. First, we examine whether the cognitive task measures we construct are indeed associated with higher wage returns, more flexibility (in terms of time schedule and work location), greater work demands and higher work pressure, as past research on cognitive work has suggested. In this way we check whether our measures reflect the phenomena we discussed earlier. Second, we study the developments in cognitive task measures over time to see whether our measures indicate an increase in the cognitive task content of work, as might be expected based on the past literature.

First, to examine if the measures of cognitive task content of work are indeed related to higher wage returns, greater flexibility, and also higher work intensity, we pool two waves of the BIBB Employment Survey (2006, 2018). We next regress our measures (measured on the continuous scale) against the following set of work characteristics: working overtime (binary), working under pressure (ordinal with four levels, with higher values reflecting more work pressure), working from home (binary), and monthly gross wages, and also time dummies and two socio-demographic characteristics (age, education). The findings from these models are presented in Appendix Table A1, by sex and task measure. They are largely in line with our expectations and suggest that workers who are employed in occupations that require them to perform cognitive tasks enjoy greater work flexibility but also experience more job strain and work longer hours. We also find a significant positive relationship between the analytic task measure and wages, although there is no association between wages and the interactive measure for women. This finding is supported by the work of Matysiak et al. (2024) who showed that women are over-represented in 'outward oriented' interpersonal tasks (e.g. care, teaching), which are associated with lower wage returns than the 'inward oriented' social tasks (e.g. managerial) exercised largely by men.

Second, we examine whether our measures point to an increase in the cognitive task content of work in our sample over time, as would be expected on the basis of past research. Figure 1 displays the distribution of our main independent variables for our first-birth sample (comprising nulliparous women and men). It points to a dramatic decline in occupations with low cognitive task intensity and an increase in occupations with medium cognitive task intensity among childless women and men. It also shows that childless individuals hardly ever worked in highly cognitive occupations in the 1980s and early 1990s, with such roles starting gradually only later. Finally, the figures indicate that childless men in our sample take on occupations characterized by high analytic task intensity more often than women, whereas women are more often in occupations that display high social/interactive task intensity. This observation is expected, as women are over-represented in professions that require human interactions (Matysiak et al. 2024) but under-represented in STEM occupations (those involving science, technology, engineering, and mathematics; Eurostat 2022).

Cognitive work and first birth: Overall association

We now move to a discussion of the relationships between cognitive work and first-birth transitions. Figure 2 presents the average predicted probabilities of first birth by respondents' cognitive task intensity from Model 1 (full results are presented in Appendix

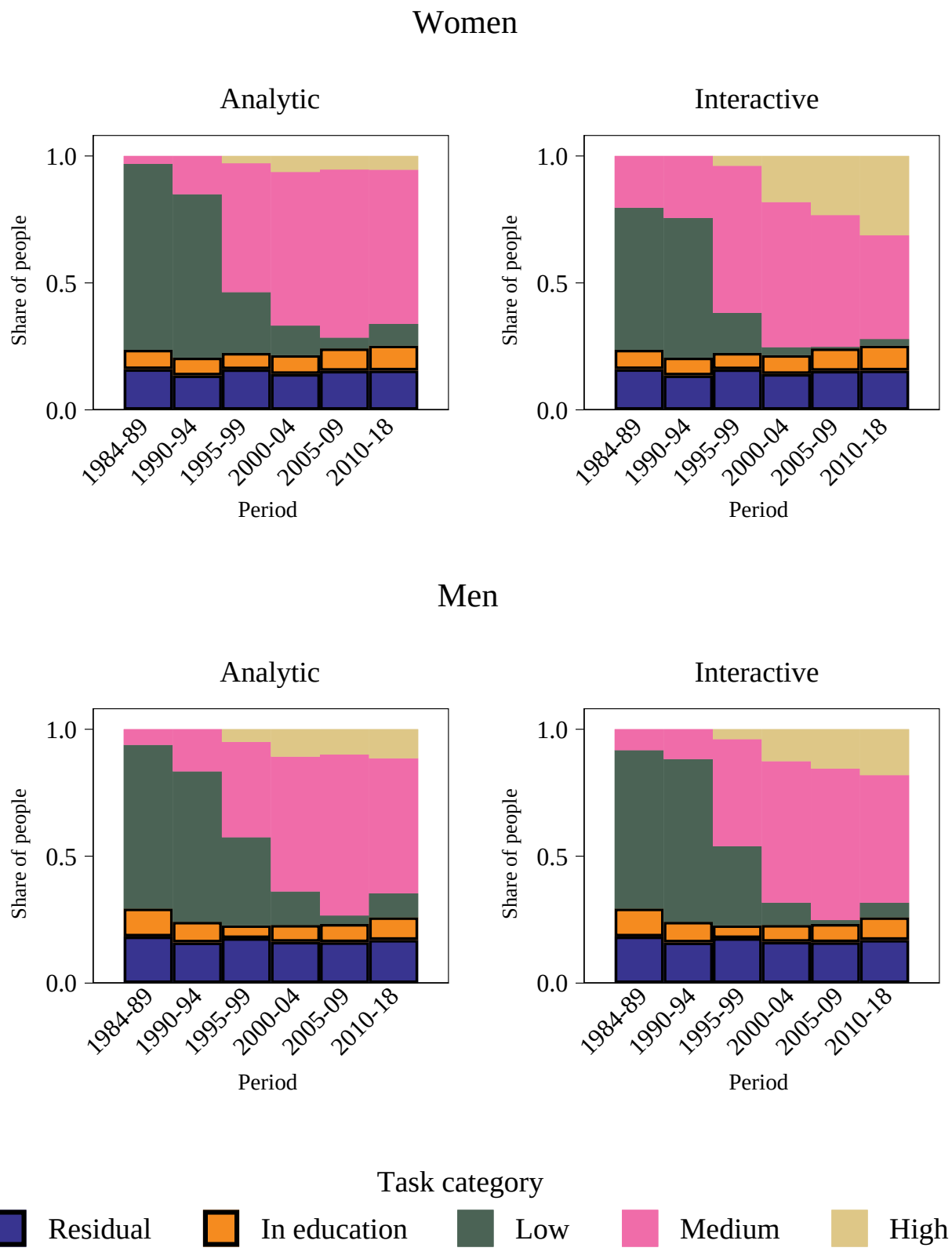

Figure 1 Share of nulliparous GSOEP respondents by task category, sex, and calendar period, Germany
Note: Person-years = 45,177 for women, 56,263 for men. The residual category is composed of inactive, unemployed, and individuals with missing occupation. Low, medium, and high refer to intensity of cognitive tasks.
Source: Authors' analysis of data from BIBB Employment Survey and GSOEP.

Table A2). The figure shows low first-birth rates for women and men who are in education. First-birth rates are also low for the residual category (composed of individuals who are not in the labour market for reasons other than being in education). Our main interest is the effect of the analytic and

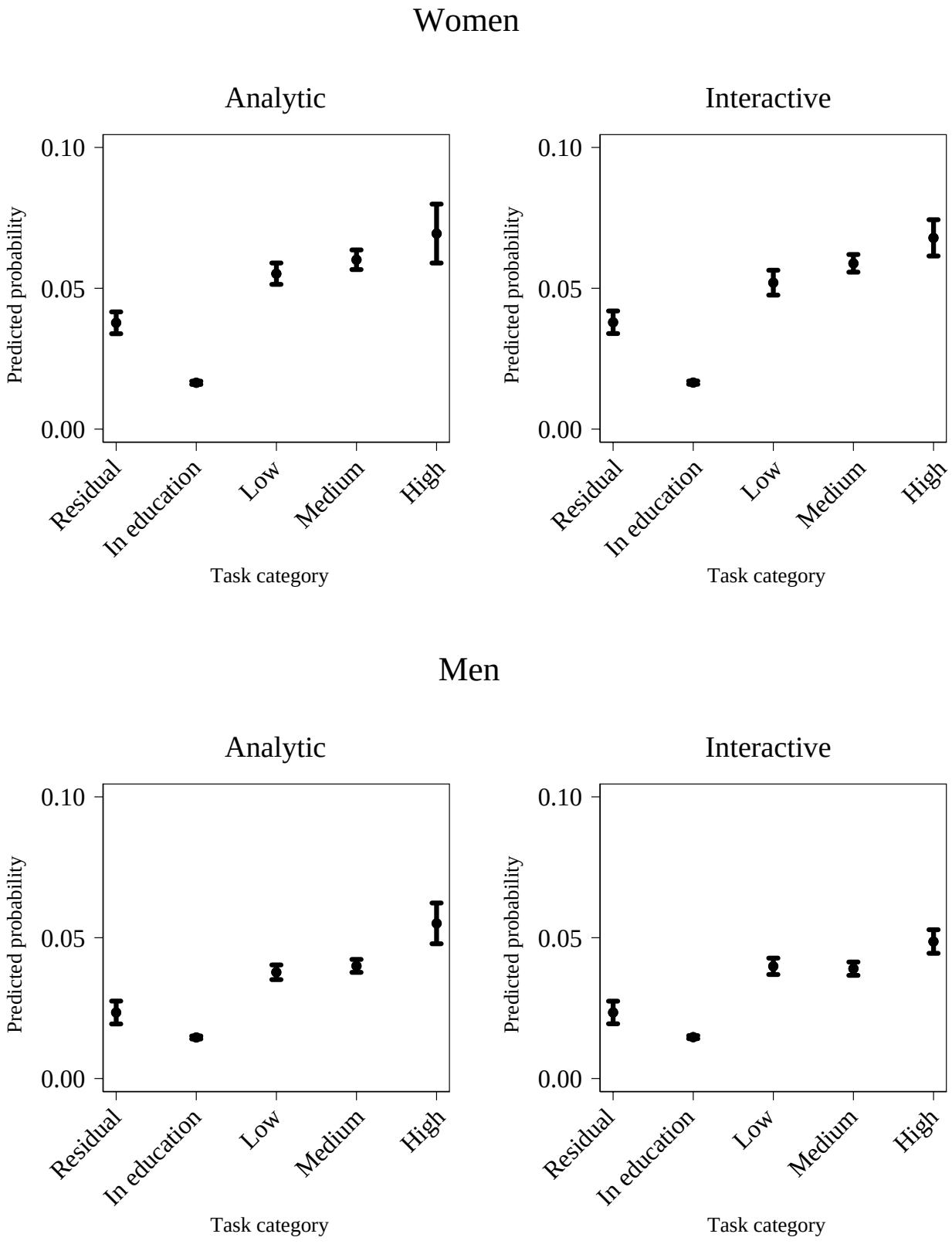

Figure 2 Average predicted probabilities from first-birth models (with 83 per cent confidence intervals), Germany

Notes: Further controls in the model are age (time-varying), period, residence (West vs East Germany), and number of siblings. Reference category = low task measure [0, 33). Person-years = 36,075 for women, 45,100 for men. Low, medium, and high refer to intensity of cognitive tasks.

Source: As for Figure 1.

interactive task measures. We observe a positive gradient for women: that is, the higher the cognitive task intensity (analytic and interactive), the higher the first-birth probability. Men in jobs with high analytic or interactive task intensity exhibit significantly higher first-birth probabilities than men in jobs with low or medium task intensity. There is no difference in first-birth probabilities between men in jobs with low and medium task intensity.

Developments over time

In the second step of our analysis, we interact the task measures with calendar period to study how first-birth probabilities have evolved over time for people with different levels of cognitive task intensity (Model 2). Figure 3 presents the average predicted annual probabilities from those estimations. The findings are similar for both task measures. We note a decline over time in first-birth probabilities for women and men in jobs with low cognitive task intensity (both analytic and social/interactive), for women and men in education, and for non-working women. At the same time, we see that first-birth probabilities have hardly changed over time for women and men in jobs with medium or higher levels of cognitive task intensity. The only exception is for women in jobs with high social/interactive task intensity, among whom first-birth probabilities increased somewhat between 2000–07 and 2008–18.

Interaction with age

Next, we interact task measures with age (Model 3) as we expect that, among respondents in jobs with high task intensities, transition to first birth will be accelerated at higher ages, as such respondents enter the labour market later and may postpone childbearing due to career considerations. Thus, they would be expected to face greater pressure to have children in a shorter time window. The results presented in Figure 4 support this view. The first-birth schedules for women and men in jobs with medium and high task intensities are different from those for other men and women. We see that the birth probabilities for these groups peak at later ages. For women who perform tasks with low cognitive intensity, first-birth probabilities peak at ages 25–29, and for those who perform tasks of medium cognitive intensity the peak is at ages 30–34, whereas for women in jobs with high cognitive task intensity it extends to ages 35–39. The overall pattern is similar for men with the difference that first births are even more delayed.

Cumulative incidence

So far, we have demonstrated that individuals with highly cognitive jobs exhibit higher first-birth probabilities than those whose jobs require low cognitive task intensity and that the differences in first-birth probabilities between the two categories have increased over time. We have also seen that individuals who eventually work in jobs high in cognitive task intensity tend to postpone childbearing until they acquire the necessary skills to take on such jobs and accelerate their entry to parenthood afterwards. A question which emerges here is whether the raised first-birth intensities among workers with highly cognitive jobs can be attributed only to these shifts in first-birth timing or whether these individuals are also becoming less likely to be childless than those in jobs with low cognitive task intensity.

The results from the standard event-history models do not readily answer this question. However, using the event-history model results to calculate cumulative incidence curves helps to display the results in a manner that enables us to gauge differences in timing and quantum. To this end, we first estimate Models 4a–b, in which task intensity is interacted with respondents' age. Further, the models are estimated on two subsamples (for the periods 1984–99 and 2000–18). We next compute the cumulative incidence, which is defined as 1 – survivor function (calculated from the predicted hazard). Unlike the hazard rate, which is often less accessible, it provides a straightforward indicator: the proportion of respondents who have experienced the event of interest by each age.

The cumulative incidence curves for the three ideal type cases are presented in Figure 5 (analytic tasks) and Figure 6 (interactive tasks). We start by interpreting the findings from the more recent period (2000–18). We find that men who eventually reach high cognitive task intensity (either analytic or social/interactive) initially display lower first-birth probabilities than men with low cognitive task intensity (Case 3 vs Case 1). This situation reverses, however, as they age: men who eventually achieve high cognitive task intensity display higher first-birth probabilities at ages 35+ and are less likely to remain childless than those who work in occupations with low cognitive task intensity. For women the

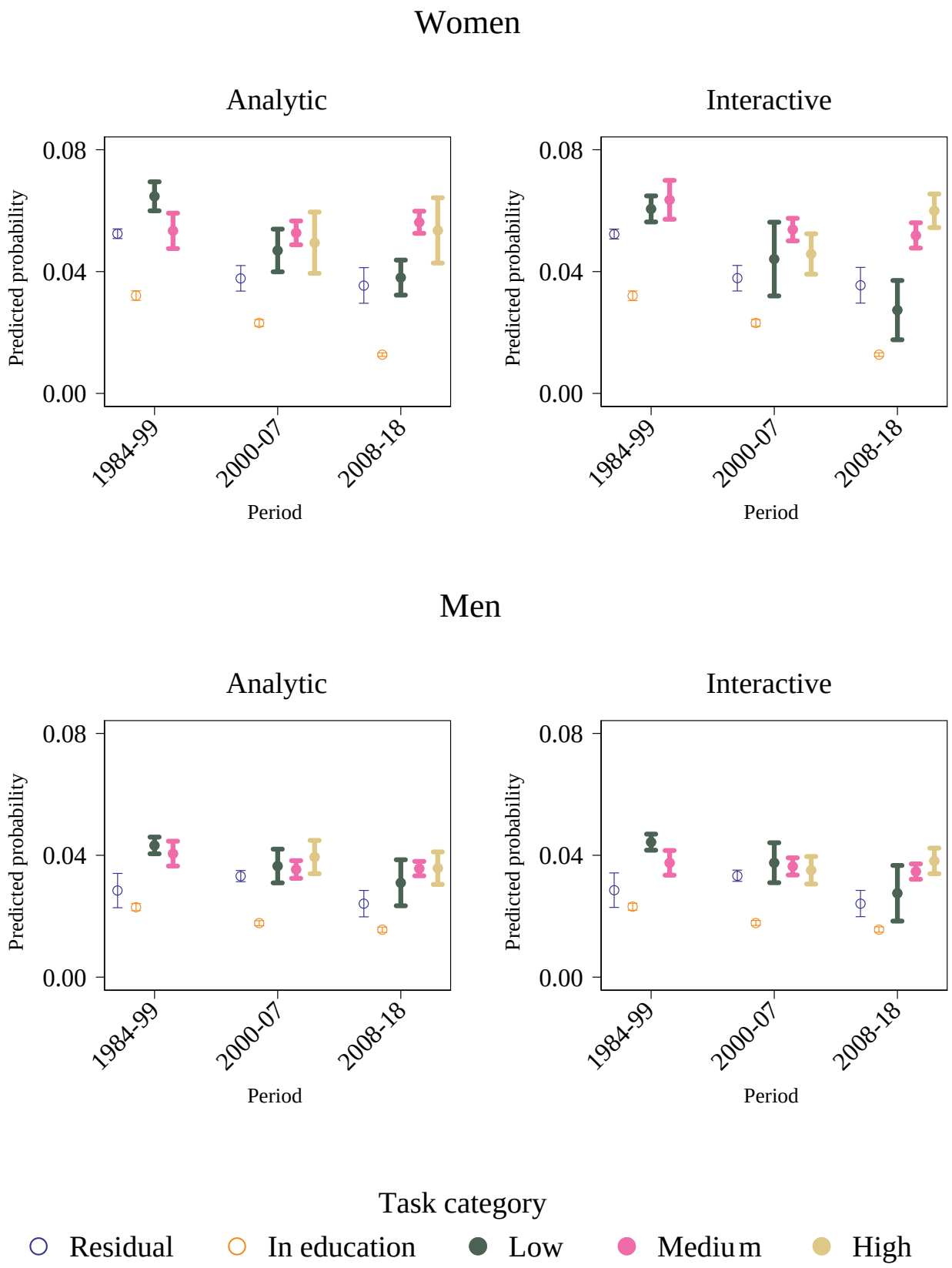

Figure 3 Average predicted probabilities from first-birth models (with 83 per cent confidence intervals): Interaction of respondents' task measures with period, Germany

Note: Further controls in the model are age (time-varying), residence (West vs East Germany), and number of siblings. Person-years = 36,039 for women, 44,990 for men. Low, medium, and high refer to intensity of cognitive tasks. We do not observe workers with high cognitive task intensity before 2000.

Source: As for Figure 1.

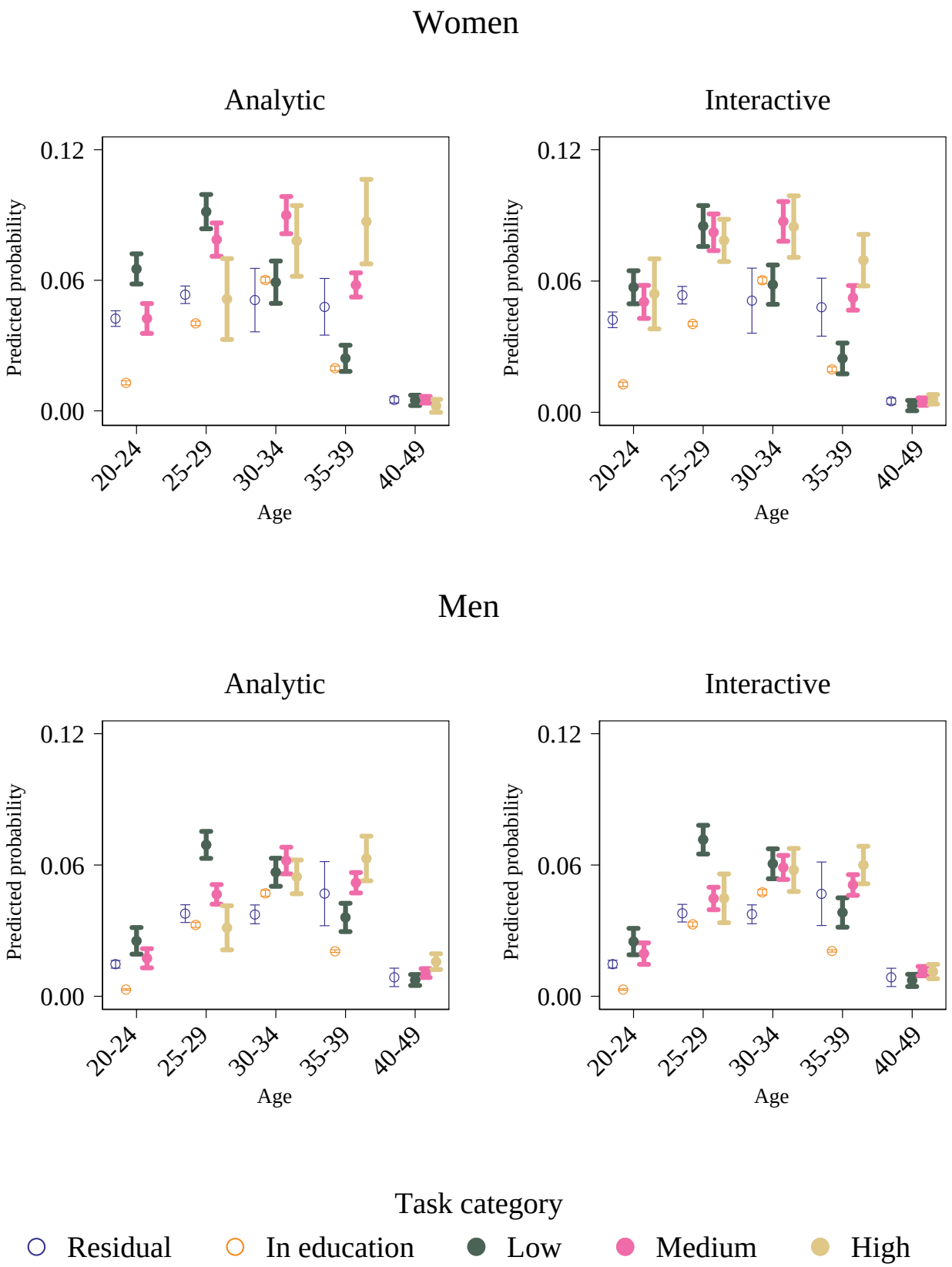

Figure 4 Average predicted probabilities from first-birth models (with 83 per cent confidence intervals): Interaction of respondents' task measures with age (time-varying), Germany

Notes: Further controls in the model are period, residence (West vs East Germany), and number of siblings. Person-years = 35,964 for women, 44,883 for men. Low, medium, and high refer to intensity of cognitive tasks.

Source: As for Figure 1.

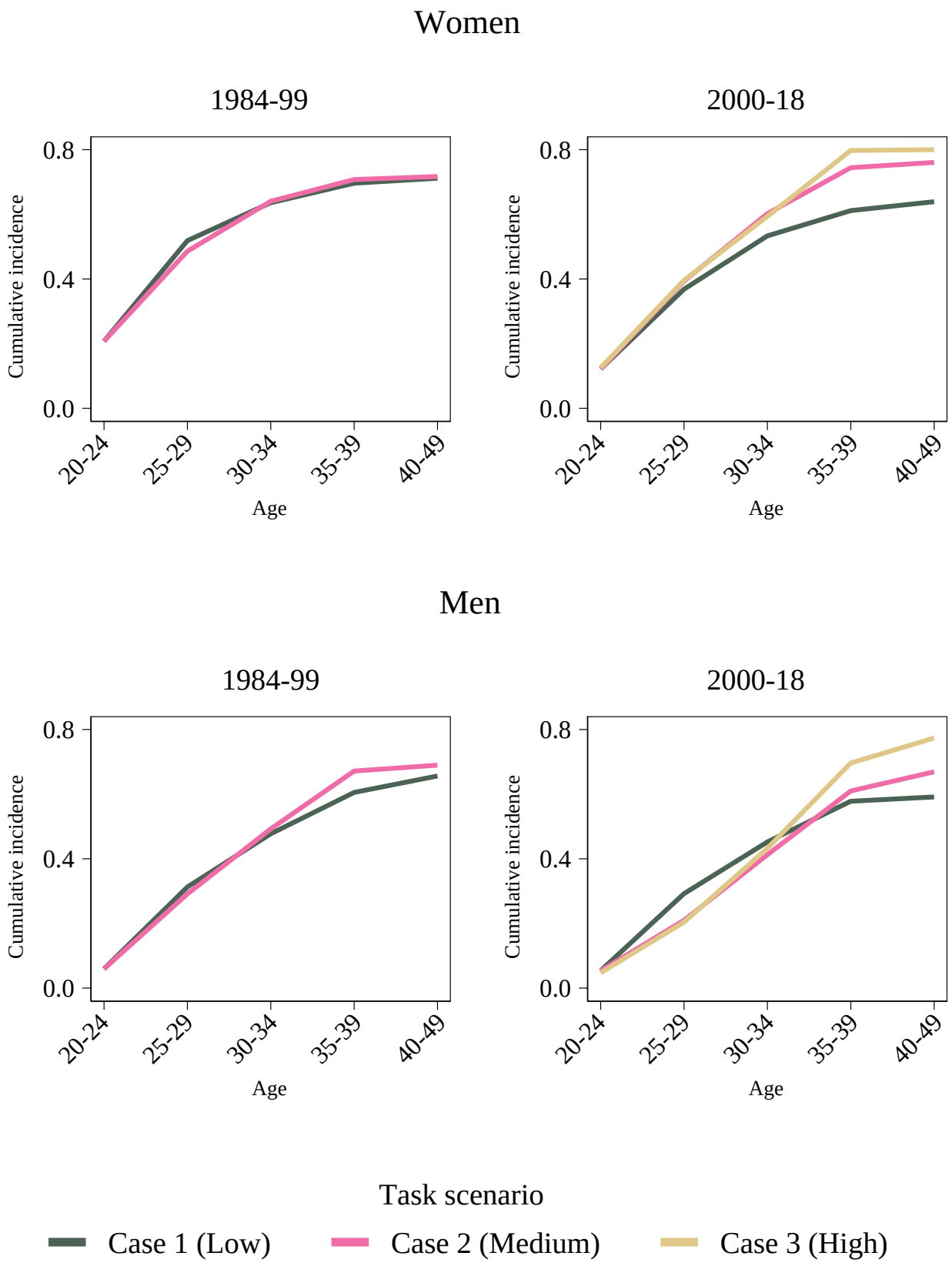

Figure 5 Cumulative incidence of first birth calculated from models with an interaction of *analytic* task measure and respondent age, Germany

Notes: For model results, see Figure 4. Case 1: a person who enters the labour market before age 20 and then has a job with low analytic task intensity. Case 2: a person who is in education until age 24 and then has a job with medium analytic task intensity. Case 3: a person is in education until age 29 and then has a job with high analytic task intensity. Other covariates are set to: residence = West Germany; number of siblings = one. We do not observe workers with high cognitive task intensity before 2000. For 1984–99: person-years = 10,917 for women, 15,113 for men. For 2000–18: person-years = 25,273 for women, 30,044 for men.

Source: As for Figure 1.

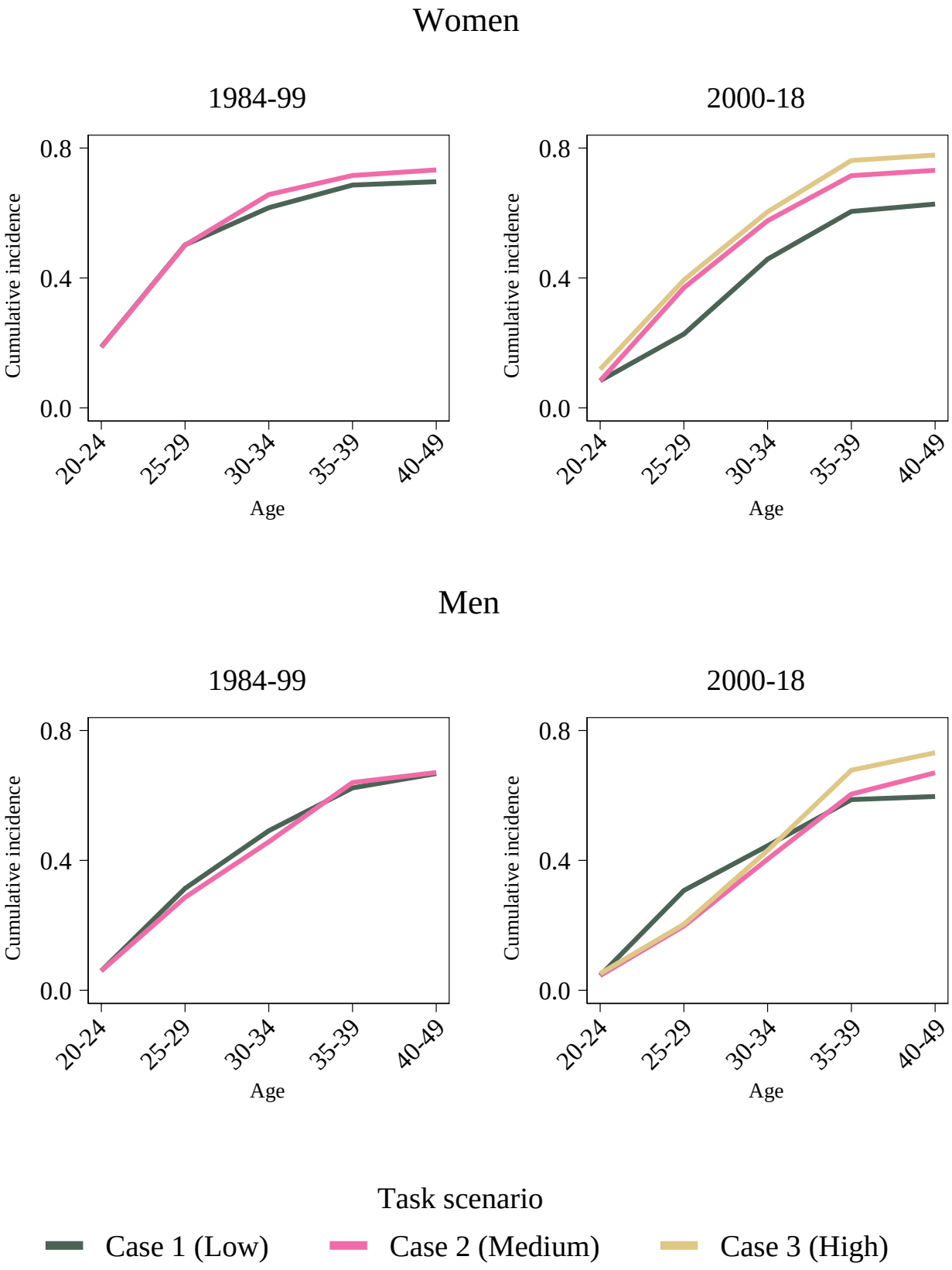

Figure 6 Cumulative incidence of first birth calculated from models with an interaction of *interactive* task measure and respondent age, Germany

Notes: For model results, see Figure 4. Case 1: a person who enters the labour market before age 20 and then has a job with low interactive task intensity. Case 2: a person is in education until age 24 and then has a job with medium task interactive intensity. Case 3: a person is in education until age 29 and then has a job with high interactive task intensity. Other covariates are set to: residence = West Germany; number of siblings = one. We do not observe workers with high cognitive task intensity before 2000. For 1984–1999: person-years = 10,929 for women, 15,148 for men. For 2000–18: person-years = 25,273 for women, 30,044 for men.

Source: As for Figure 1.

pattern is slightly different. Women who end up in jobs with medium/high analytic task intensity (Cases 2 and 3; Figure 5) tend to postpone motherhood during their 20s to the same extent as women who end up in jobs with low analytic task intensity (Case 1). Nonetheless, the former still accelerate childbearing at older ages and are in the end less likely to remain childless. Women in occupations with medium/high social/interactive task intensity (Figure 6) are also less likely to remain childless than those in occupations with low social/interactive task intensity, but the relative advantage of the former emerges at younger ages and prevails throughout their life courses.

Patterns were rather different in the earlier period (1984–99). As already noted, occupations that require a high task intensity barely existed in practice at that time. Furthermore, the fertility schedules of people who eventually achieved jobs with low or medium cognitive task intensity were similar, in terms of both first-birth timing and the probability of remaining childless.

Robustness checks

We also conduct two robustness checks. In our main models, we excluded people with non-German citizenship, as foreigners and migrants in Germany typically exhibit different fertility schedules from the native born (Milewski 2010). As a first robustness check, we repeat the (main) first-birth model for individuals and include non-German citizens but control for citizenship. Second, we redefine the categorial task measures by imputing occupation linearly interpolated independently from labour force status (except for individuals in education). Thus, we account for the fact that joblessness might be a temporary status, which is not always indicative of an individual's labour market prospects. The findings from these two robustness checks are presented in Appendix Figures A2 and A3, respectively. The robustness checks do not yield significantly different findings from our (main) model presented in Figure 2. Thus, we conclude that our models are reasonably robust to the inclusion/exclusion of migrant populations or specific definitions of task measures.

Discussion

Globalization and technological change have led to tremendous changes in the labour market. These changes—reflected in increased demand for cognitive skills, expansion of flexible work schedules, and greater emphasis on workers' performance—have led to a divergence of labour market opportunities for cognitive and non-cognitive workers. Moreover, while a large body of demographic research has demonstrated that labour market opportunities are important determinants of fertility behaviours, hardly any research has been conducted on how these diverging opportunities between cognitive and non-cognitive workers have affected their childbearing behaviours. In our study, we sought to fill this research gap by focusing on the transition to parenthood. Drawing on the literature on the task content of occupations, we classified occupations into three groups, ranging from those that involve low cognitive intensity tasks to those that involve highly cognitive work. We conducted our study in Germany, which transitioned to a knowledge economy from the late 1960s and where demand for highly skilled labour is currently strong.

The results of our analysis support the findings from prior labour market research, which has indicated that young individuals in Germany currently work in completely different occupations from three decades ago (Baumgarten et al. 2020; Koomen and Backes-Gellner 2022). Based on a sample of nulliparous women and men, we showed that jobs currently considered high in cognitive task intensity barely existed in the 1980s. In fact, such jobs started to appear and gain importance among young childless individuals in the 1990s. We also demonstrated that these young adults, who had not yet become parents, were currently far more likely to work in occupations characterized by medium cognitive task intensity and less likely to be in occupations with low cognitive task intensity than in the past. In fact, occupations with low cognitive task intensity turned out to be marginal in our sample of women and men from 2000–04 onwards.

At the same time, we found that cognitive task intensity was tightly associated with entry to parenthood for both women and men. Specifically, we found that both women and men with highly cognitive jobs were on average more likely to become parents than those with non-cognitive jobs, supporting Hypothesis 1a. However, a more detailed analysis of these relationships revealed some changes over time as the structural changes in the labour market progressed, destroying employment opportunities for low-skilled workers. While first-birth probabilities for non-working women and workers in jobs with low cognitive intensity were fairly high in the late 1980s and 1990s, they later

decreased below the levels observed for workers with medium and high task intensities. We also observed that women working in occupations which require high cognitive task intensity displayed an increase in first-birth probabilities during the most recent decade. Consistent with Hypothesis 1b, these developments have led to a divergence in first-birth intensities with respect to workers' cognitive task intensity.

In the next step of the analysis, we investigated whether these patterns had been driven by changes in fertility quantum or only by an acceleration of the transition to parenthood at high reproductive ages among workers who acquire jobs high in cognitive tasks only at more advanced ages. We indeed found that individuals who reached high cognitive task intensity were initially most likely to postpone entry to parenthood and then accelerate it afterwards. However, we also demonstrated that these workers were eventually most likely to become parents by age 50 and thus the least likely to remain childless. The only exception was women who worked in occupations high in social/interactive tasks: these women were also less likely to remain childless than those in occupations with low social/interactive task intensity but they built their advantage in childbearing earlier in the life course. All in all, however, these findings imply that the structural labour market changes have benefited highly cognitive workers and are likely to result in higher (although delayed) fertility among highly skilled workers in comparison to the low skilled.

We also investigated whether the associations between cognitive task intensity and first-birth probabilities became more similar for women and men over time (Hypothesis 2a) and whether they varied by the type of cognitive task (analytic vs social/interactive; Hypothesis 2b). Our findings indeed lend support to Hypothesis 2a, as we observed a clear decline in first-birth intensities among women with low cognitive task intensities and among non-working women. As a result of these changes, the patterns in cognitive work and transition to parenthood became more similar among women and men. These findings signify an important change in gender roles, with women's economic position becoming an increasingly important factor in family formation. At the same time, some slight differences between women and men emerged when it came to the type of cognitive tasks they performed (Hypothesis 2b). Women and men with high analytic task intensity were both more likely to have a child by age 50 than those with low analytic task intensity. However, high social/interactive task intensity was far more positively related to childbearing among women than men. This latter finding was contrary to our expectations, as we had presupposed that social/interactive task intensity would be more positively related to first-birth probabilities among men as they tend to work on social/interactive tasks that are better paid compared with women (i.e. managerial tasks) (Matysiak et al. 2024). This is likely caused by the fact that jobs rich in managerial tasks are associated with higher time pressure and uncertainty than jobs in the care sector or education.

All in all, these findings suggest that the structural changes in labour demand brought about by technology and globalization have led to important shifts in the conditions for family formation. These conditions have improved for women and men who have adjusted to current labour market demands by performing cognitive tasks. At the same time, the conditions for earning income and combining paid work with family life have worsened for all other workers, who are being increasingly left behind, in terms of their options not only for engaging in economic activity and earning income but also for having a family. Consistent with our expectations, we observed that as the structural labour market changes progressed, workers with highly cognitive jobs became more likely to enter parenthood (and less likely to remain childless) than workers with non-cognitive occupations and the non-employed. As these labour market changes will likely continue, with technologies further increasing the demand for the most skilled labour and destroying jobs for the less skilled, we may observe further increases in first-birth disparities between these two groups of workers in future.

Despite being novel, our study had important limitations. Due to data constraints, we could not perform a more detailed assessment of the task content of occupations that do not require cognitive skills. Although research has established at least two types of such tasks—namely, repetitive/routine tasks, which are most likely to be automated or offshored; and non-routine manual tasks—we were not able to quantify them consistently in a longitudinal setting (Rohrbach-Schmidt and Tiemann 2013). Thus, while we could draw conclusions about the fertility behaviours of individuals in occupations with low cognitive task content, we could not examine whether the workers who were at greatest risk of being affected by the ongoing changes (i.e. those performing routine tasks) were most likely to postpone parenthood. Furthermore, we were not able to measure the task content of work at the individual

level because information about job tasks is not usually available in longitudinal surveys. For this reason, we had to rely on occupational task measures. Although such measures have been widely applied in top-level research in labour economics (Autor et al. 2003; Autor and Dorn 2013), they conflate the variation in work tasks across individual jobs (Autor and Handel 2013).

Finally, our models suffered from some methodological shortcomings. Selection was an omnipresent problem. We could not rule out the possibility that women (and men) selected themselves into occupations based on their fertility intentions, and this may even have affected the first occupation they chose post education. Another important limitation was that our data did not allow us to control for partner's occupational status in our models. This was due to the relatively low fraction of couple households in which both partners were present at the interview and could participate in the GSOEP. Taking a couple approach would thus have substantially reduced our sample and limited the opportunities for conducting a reliable study.

Despite these limitations, our study is one of the first to investigate the impact of structural labour market changes on entry to parenthood. Only a few previous studies have addressed this problem, namely Seltzer (2019), Matysiak et al. (2023), and Anelli et al (2024), but they all adopted a macro-level approach. In our study, we took a first step towards providing a theoretical conceptualization and empirical assessment of labour market prospects and their role in fertility at the individual level. Further research on this topic needs to apply more refined measures and a cross-national comparative framework. In particular, it remains unclear whether the improving conditions for family formation experienced by cognitive workers relative to non-cognitive workers are caused by better employment and earning opportunities or by the expansion of flexible work schedules that allow workers, including fathers, to better organize their professional activities around their family obligations. It is obviously vital to tease these two explanations apart because they will lead us to completely different conclusions about the gendered effects of the digital transformation of the labour market.

Notes and acknowledgements

1 Honorata Bogusz and Anna Matysiak are based in the Interdisciplinary Centre for Labour Market and Family Dynamics (LabFam), Faculty of Economic Sciences, University of Warsaw, Poland. Michaela Kreyenfeld is based at Hertie School, Berlin, Germany.

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4 Funding: This research was supported by the Polish National Agency for Academic Exchange (Polish Returns Programme 2019) and the European Research Council under the ERC Consolidator Grant 'Globalization- and Technology-Driven Labour Market Change and Fertility' (LABFER, grant agreement number 866207).

5 The authors acknowledge useful comments from John Ermisch, Wojciech Hardy, Beata Osiewalska, Christine Percheski, Daniela Rohrbach-Schmidt, and the three anonymous reviewers, as well as participants at the following conferences: PAA 2022, RC28 spring meeting 2022, EPC 2022, BSPS 2022, and 'Gender and social inequality in fertility' in Oslo, 2024.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix

Table A1 Beta coefficients from pooled OLS regression: Outcome variable = task measure (analytic or interactive)

	Women			Men	
Covariate	Analytic	Interactive		Analytic	Interactive
Working overtime: No			(Ref.)		
Working overtime: Yes	5.127***	5.530***		3.228***	5.278***
	(0.413)	(0.528)		(0.511)	(0.570)
Working under pressure: Never			(Ref.)		
Working under pressure: Seldom	10.100***	8.824***		12.010***	6.323***
	(0.995)	(1.273)		(1.376)	(1.533)
Working under pressure: Sometimes	14.28***	13.82***		17.32***	12.52***
	(0.889)	(1.138)		(1.272)	(1.417)
Working under pressure: Frequently	16.64***	15.63***		18.54***	15.73***
	(0.879)	(1.125)		(1.255)	(1.399)
Monthly wage	0.010*	−0.010		0.018***	0.015**
	(0.005)	(0.007)		(0.006)	(0.007)
Education: Low			(Ref.)		
Education: Middle	10.17***	11.56***		6.504***	8.364***
	(0.691)	(0.884)		(0.723)	(0.807)
Education: High	19.02***	15.89***		17.23***	15.63***
	(0.759)	(0.970)		(0.771)	(0.860)
Work from home: Yes	11.29***	13.66***		14.16***	15.70***
	(0.429)	(0.549)		(0.477)	(0.532)
N	13,489	13,497		13,320	13,317

Notes: *** 1 per cent, ** 5 per cent, * 10 per cent. Further controls include age and calendar year. Standard errors in parentheses. (Ref.) is the reference category.
Source: Regressions were conducted on pooled BIBB Employment Survey waves for 2006 and 2018.

Table A2 Full results from first-birth models without interactions

Covariate	Women			Men	
	Analytic	Interactive		Analytic	Interactive
Task measure: Residual	0.675***	0.614***		0.722***	0.581***
	(0.048)	(0.089)		(0.055)	(0.083)
Task measure: In education	0.290***	0.379***		0.309***	0.362***
	(0.018)	(0.020)		(0.022)	(0.019)
Task measure: Low			(Ref.)		
Task measure: Medium	1.094	1.062		1.138*	0.978
	(0.077)	(0.080)		(0.083)	(0.073)
Task measure: High	1.271*	1.480***		1.322***	1.229**
	(0.163)	(0.179)		(0.142)	(0.116)
Period: 1984–99			(Ref.)		
Period: 2000–07	0.743***	0.779***		0.718***	0.818**
	(0.056)	(0.063)		(0.054)	(0.066)
Period: 2008–18	0.729***	0.734***		0.690***	0.767***
	(0.070)	(0.053)		(0.066)	(0.058)
Age: 20–24			(Ref.)		
Age: 25–29	2.635***	5.069***		2.641***	5.095***
	(0.160)	(0.495)		(0.159)	(0.497)
Age: 30–34	2.959***	7.381***		2.966***	7.514***
	(0.270)	(0.783)		(0.269)	(0.797)
Age: 35–39	1.985***	6.770***		1.982***	6.902***
	(0.199)	(0.729)		(0.195)	(0.755)
Age: 40–49	0.191***	1.515***		0.191***	1.531***
	(0.0350)	(0.218)		(0.035)	(0.224)

(*Continued*)

Table A2 Continued.

Covariate	Women			Men	
	Analytic	Interactive		Analytic	Interactive
Number of siblings: Zero			(Ref.)		
Number of siblings: One	1.074	1.099		1.075	1.108
	(0.071)	(0.076)		(0.069)	(0.076)
Number of siblings: Two or more	1.192***	1.213***		1.190***	1.208***
	(0.071)	(0.084)		(0.071)	(0.084)
West Germany			(Ref.)		
East Germany	1.292***	0.955		1.293***	0.958
	(0.104)	(0.067)		(0.104)	(0.068)
N	36,076	45,100		36,076	45,100
AIC	13,322.9	12,771.4		13,320.4	12,781.8
Log-likelihood	−6,646.5	−6,371.7		−6,644.2	−6,375.9

Notes: *** 1 per cent, ** 5 per cent, * 10 per cent. Exponentiated coefficients. Standard errors in parentheses. Task measures and residence (West vs East Germany) are time-varying and are lagged by two years. Other covariates are time-constant. (Ref.) is the reference category.
Source: Authors' analysis of data from BIBB Employment Survey and GSOEP.

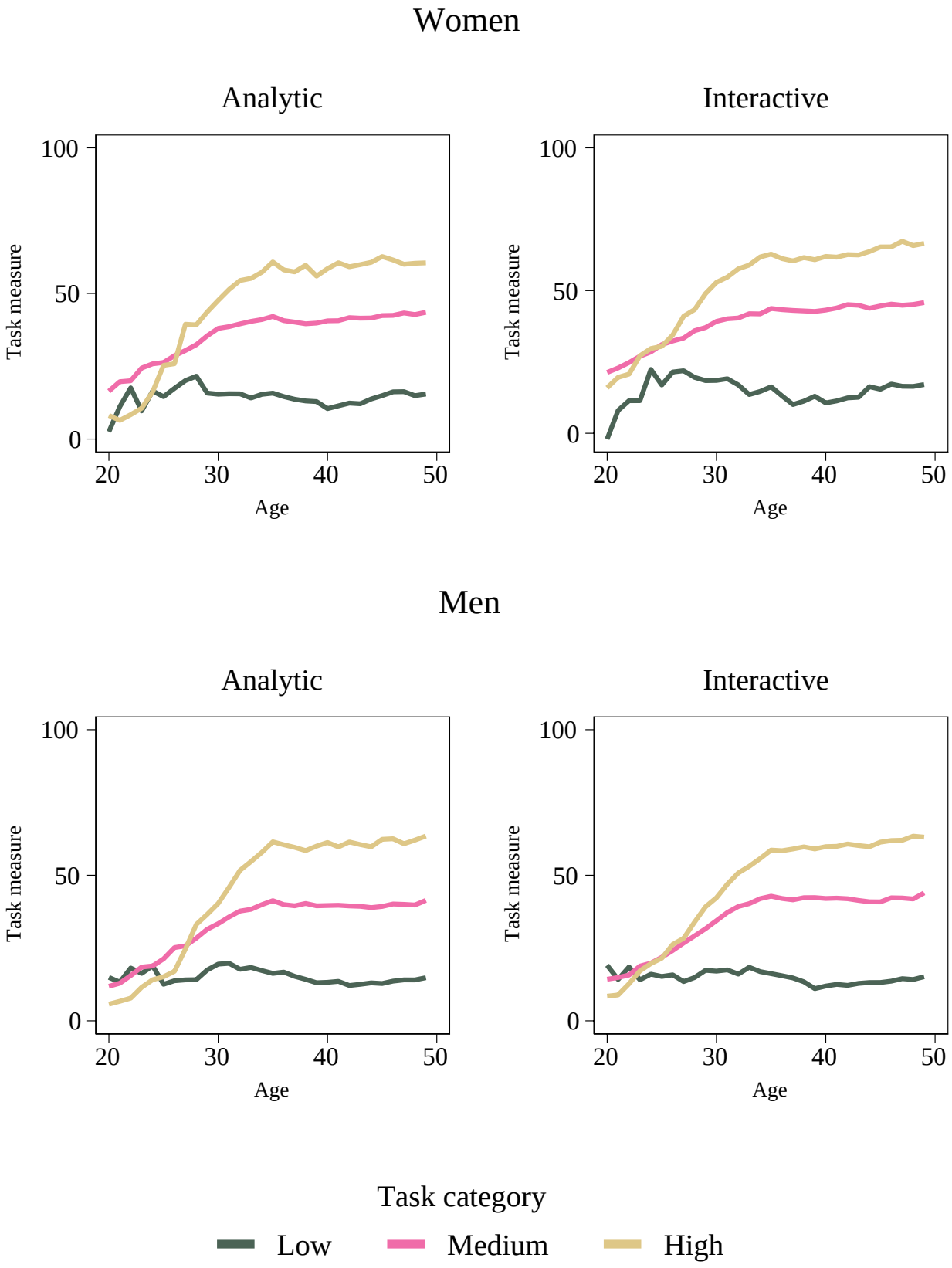

Figure A1 Mean analytic task measure by highest task measure achieved at age 35+: Patterns by sex and age
Notes: Unweighted estimates from employed respondents in analytical sample. Person-years at age 35+ = 16,353 for women, 24,695 for men.
Source: Authors' analysis of data from BIBB Employment Survey and GSOEP.

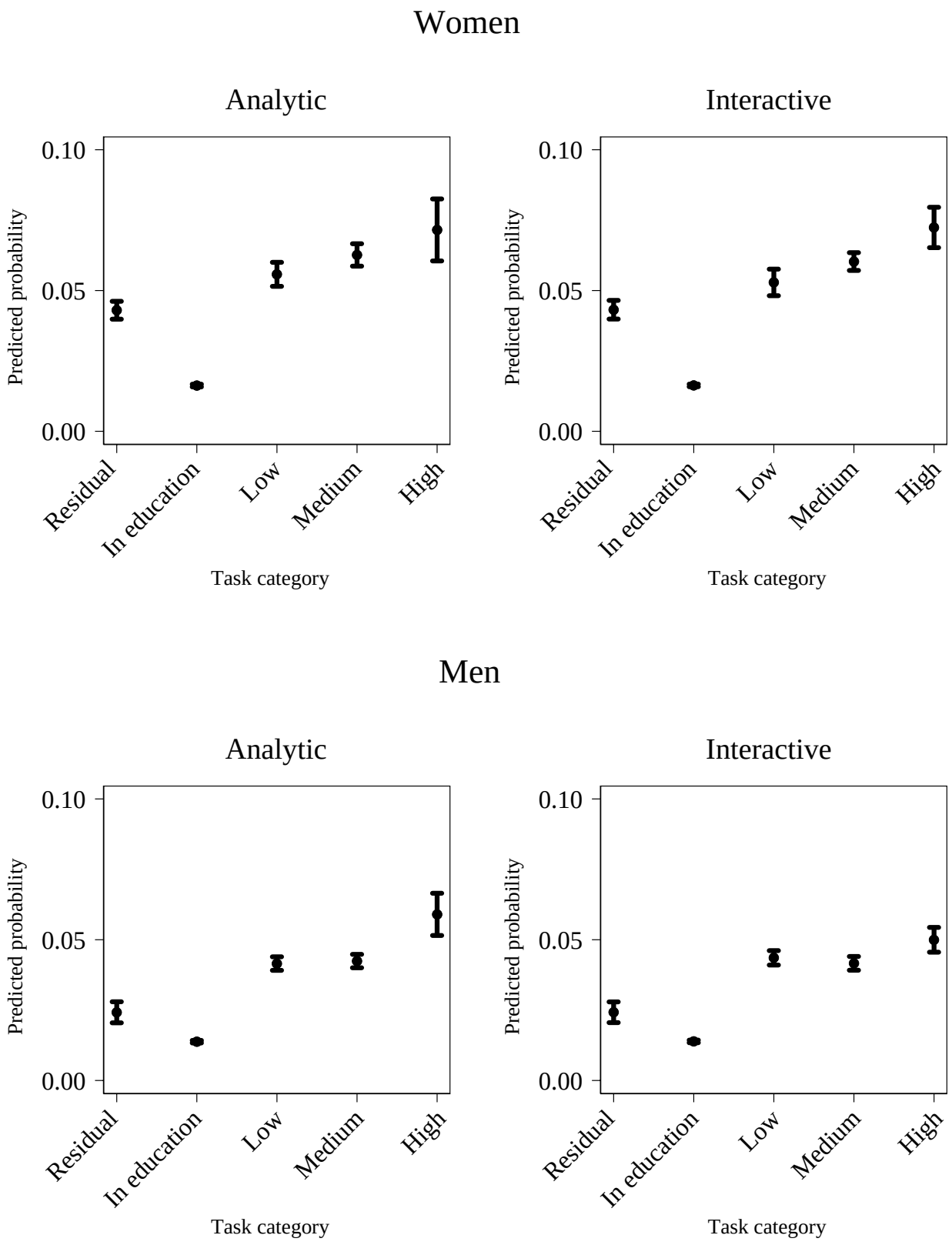

Figure A2 Average predicted probabilities from first-birth models (with 83 per cent confidence intervals): Robustness check including migrants and controlling for German citizenship status

Notes: Further controls in the model are age (time-varying), period, residence (West vs East Germany), and number of siblings. Reference category = low task measure [0, 33). Person-years = 40,313 for women, 50,816 for men.

Source: As for Figure A1.

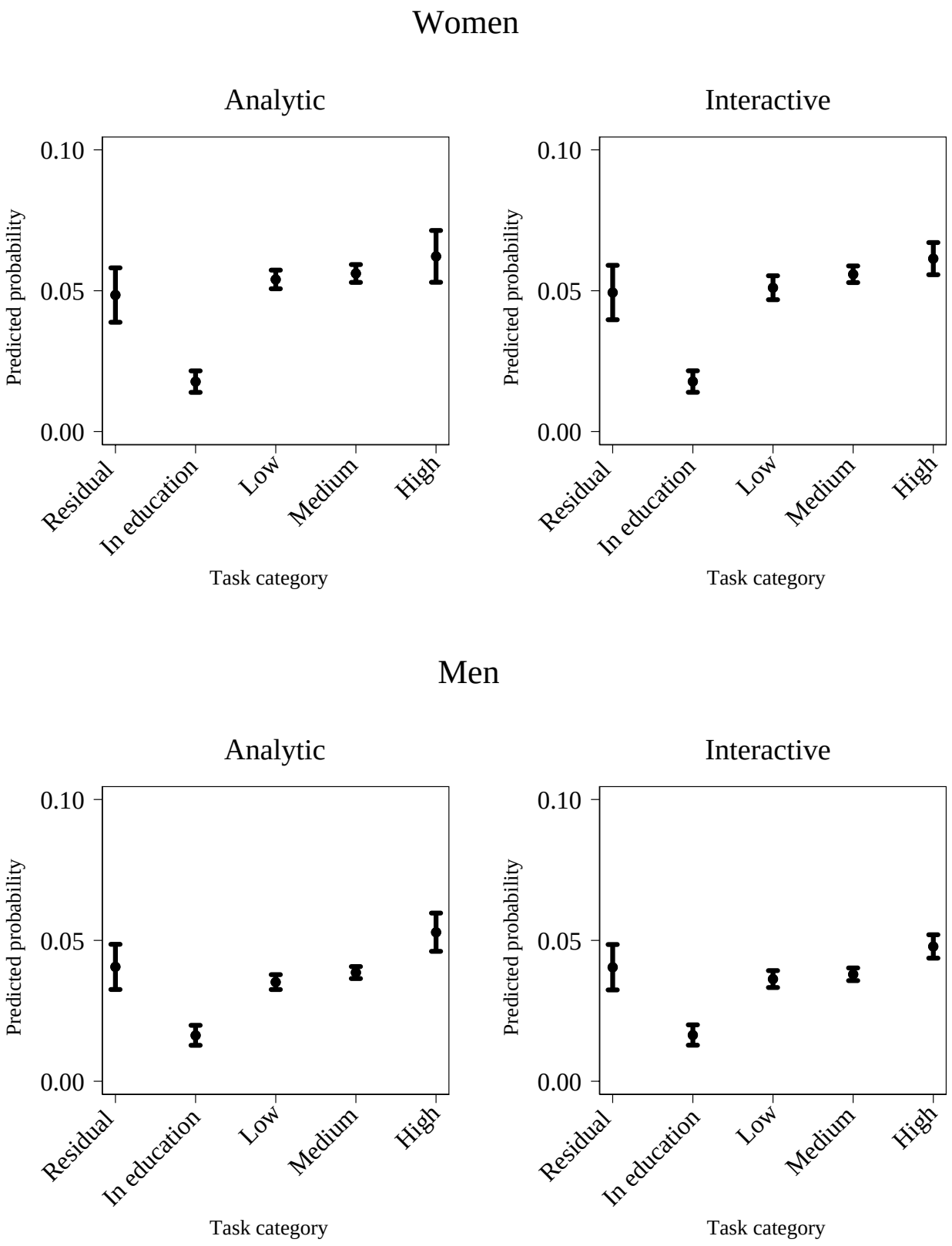

Figure A3 Average predicted probabilities from first-birth models (with 83 per cent confidence intervals): Robustness check with task measures redefined in a way where occupation is linearly interpolated independent of labour market status

Notes: Further controls in the model are age (time-varying), period, residence (West vs East Germany), and number of siblings. Reference category = low task measure [0, 33). Person-years = 34,387 for women, 43,150 for men.

Source: As for Figure A1.