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Childbearing in the Knowledge-Based Society: Job-Related Learning Demands and the Transition to Parenthood in Germany

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Abstract: This study investigates the relationship between learning demands at work and the transition to parenthood in Germany. As a consequence of technological progress and intensifying global competition, workplace learning is no longer an optional path to career advancement but has become an essential job demand. Consequently, it absorbs time and energy that could otherwise be devoted to family formation, prompting individuals to postpone childbearing or have fewer children. Yet, the fertility implications of this structural change have not been systematically examined. This study addresses this gap by analysing how job-related high learning demands relate to the transition to the first birth. The results indicate that individuals in jobs with high learning demands, both men and women, tend to delay the transition to the first birth. However, these delays do not appear to preclude them from becoming parents later, suggesting a postponement rather than a withdrawal from parenthood.

Keywords: fertility, childbearing, learning demands, labour market transformation, work-family conflict

JEL codes: J13, J16, J22, J24

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1. Introduction

In knowledge-based economies, rapid technological advancements and intensified global competition continuously reshape skill requirements, affecting workplace dynamics and individuals' roles within institutions. Emerging technologies, such as AI, are accelerating these shifts in skill demands and career pathways, making continuous learning and the ability to acquire and apply new knowledge at work increasingly important for both individual employability and organizational resilience (Frank et al., 2019).To remain competitive, workers need to engage in ongoing learning to keep their knowledge up to date, upgrade their skills, and adapt to the latest rules and policies (Loon & Casimir, 2008; Obschonka et al., 2012). As a result, workplace learning is no longer an option that benefits career development but has become an essential job demand—one that requires effort and often entails personal costs (Houben et al., 2021; OECD, 2016).

Despite the growing importance of updating one's knowledge in the working life, little is known about how job-related learning demands interplay with personal life choices, particularly those that may not be compatible with ongoing occupational training, such as childbearing. High learning demands in the workplace may affect transition to parenthood as they often entail higher opportunity costs of childbearing and intensify conflicts between occupational careers and family life, in particular for women. Maternity leave, for instance, interrupts training and skill development, and rapid technological and workplace innovations lead to quicker depreciation of human capital, making reintegration into the labour force after the break more challenging (Bartoš & Pertold-Gebicka, 2018). For both men and women, the time and effort required for continuous upskilling may reduce the time available for family life. That may lead to delaying or foregoing having children. Although jobs with high learning demands may offer higher income, improve workers' job stability and future employability (Clarke, 2008; Froehlich et al., 2014; Xiao, 2002) - factors which may ultimately facilitate childbearing - these benefits typically accrue later in one's career. Before that, the competitive work environment of such workplaces may discourage early transitions to parenthood.

This study examines the association between occupation-level job-related learning demands and individual childbearing decisions. In particular we examine whether persons employed in occupations with high learning demands are more likely to postpone entry to parenthood than those working in less knowledge intensive jobs. We also investigate whether the former recuperate childbearing at later ages or are more likely to remain childless than the latter. The study is based in Germany, a country which has experienced major labour market

changes due to globalisation and technological advancements (Bogusz et al., 2025). Germany transformed into a knowledge society in the late 1960s, leading to an increase in occupational complexity and skill requirements (Rohrbach-Schmidt & Tiemann, 2013; Spitz-Oener, 2006). As a result, the shortage of skilled workers remains a major challenge for Germany to this day. According to the Federal Employment Agency (BA), approximately 439,000 vacancies for skilled workers, specialists and experts were registered in 2024 (Federal Employment Agency, 2025). To address this shortage, firms increasingly rely on workplace-based learning and expand on-the-job training to upskill and retain their workforce (Dang et al., 2025). At the same time, Germany has remained a low-fertility country for decades, with a total fertility rate below 1.6 since 1975 (United Nations, 2024). Compared to women born in 1955, permanent childlessness has increased from 16% to 20% among German women born in 1975 (OECD, 2024). Together, these demographic and labour market trends provide a compelling context for investigating how job-related learning demands may influence childbearing decisions.

To address our research objectives, we integrate individual life history data from the National Educational Panel Study (NEPS) in Germany, which includes detailed information on occupational histories and fertility behavior, with information from the Occupational Information Network (O*NET). O*NET is a comprehensive database that provides detailed information on occupational characteristics, including learning demands. We use this data to construct indicators of learning demands, which are then linked to individuals' occupational histories in NEPS to analyse how these occupational requirements relate to childbearing decisions.

This study makes two main contributions to the literature on fertility and labour market dynamics. First, it is among the first to examine how the job-related learning demands are related to the timing and likelihood of entry to parenthood. In this way, the study moves beyond the commonly examined themes of deregulation, employment instability, and nonstandard contracts, which like growing learning demands have emerged with ongoing globalisation and technological progress and to date have largely dominated demographic debates on work and family (Alderotti et al., 2021; Bastianelli et al., 2023; Kreyenfeld et al., 2012; Mills & Blossfeld, 2003; Piriu, 2022). Second, the study contributes to demographic research by demonstrating the value of linking survey data with occupational measures constructed based on the information stored in occupational databases such as Occupational Information Network (O*NET). Although such measures capture job characteristics of individuals, they provide meaningful insights into their occupational features, which are often lacking in standard social

surveys. While this approach has been commonly used in economics and sociology, it remains far less common in demography (for exceptions see Bogusz et al 2025). By applying it in his study, we thus fill this gap and offers a novel perspective to examine how changes in the labour markets influence family formation.

2. Background

2.1. Increasing learning demands in the changing world of work

Learning demands in the labour market have intensified in the recent decades due to significant changes in the social and professional environment, including ongoing technological developments, evolving organizational structures, and shifting social roles (Korunka et al., 2015). These changes require workers to regularly update their skills and knowledge to keep pace with new technologies and workflows, adapt to new social interactions and responsibilities, and manage multiple tasks efficiently. Consequently, learning demands represent a key aspect of paid work that influences employees' ability to remain competitive and effective in their roles.

The overall level of learning demands depends on the frequency of use of information and communication technology (ICT) (Mauno et al., 2019), the changes in the work situation (Kubicek et al., 2015), variety and complexity of tasks (Kubicek et al., 2015; Loon & Casimir, 2008), and the pace of technological innovation in the field (Obschonka et al., 2012). As a result, workers in some professions face more intensive learning demands than others. For example, financial quantitative analysts must continuously adapt to changing markets, new analytical models, and evolving data tools, leading to higher learning demands than accountants, whose work is guided by more stable professional standards and regulatory requirements.

2.2. Job-related learning demands and entry to parenthood

Job-related learning demands may affect childbearing decisions through several interconnected mechanisms. First, workplaces with high learning demands may offer beneficial motivational and performance benefits for employees (Mauno et al., 2020) and steep earning trajectories (Xiao, 2002). Workers who manage to keep pace with the intense learning requirements benefit most from these opportunities. They are more likely to experience greater job satisfaction, higher earnings and stronger job security (Clarke, 2008; Herttalampi et al., 2023; Kohlrausch & Rasner, 2014; Mauno et al., 2024; Xiao, 2002). Since parenthood is a long-term commitment requiring substantial and stable financial resources (van Wijk, 2024;

van Wijk & Billari, 2024), these favourable working conditions can serve as a strong foundation for starting a family (*income mechanism*). In this sense, the advantages associated with high-learning-demand jobs may theoretically support childbearing decisions.

Yet these same learning demands can simultaneously activate other mechanisms which may lead to the postponement of the entry to parenthood and even its abandonment. First, they can trigger the *opportunity costs mechanism* as outlined in the economic theory of fertility (Gauthier & Hatzius, 1997). Active participation in the workplace is essential for maintaining exposure to evolving technologies, practices, and professional networks that support skill development (Jeon & Kim, 2012; Manuti et al., 2015). Having a child necessitates taking a career break, most commonly via parental leave, by at least one of the parents, which interrupts the process of human capital accumulation, and makes reintegration into workplace more challenging. Opportunity costs are likely even higher in fast-changing work environments, skills and knowledge may quickly depreciate during a period of absence (Walter & Lee, 2022), lowering the competitive advantage of individuals returning to work after parental leave. Consequently, due to the high opportunity costs, workers in occupations with high learning demands may delay or forego childbearing.

Similar mechanism, which we call *resource preservation mechanism*, can be derived from the Conservation of Resources Theory (COR) (Hobfoll, 1989). COR defines resources as things that people value, such as objects, personal characteristics (e.g., job skills, self-esteem), conditions (e.g., employment, tenure) and energies (e.g., money, credit). It argues that individuals are motivated to protect their existing resources and to acquire new ones (Halbesleben et al., 2014). Workers in high learning-demand jobs tend to devote lots of time, energy, and cognitive effort into developing new competencies and advancing their careers. In line with COR, they are highly motivated to protect these investments and may postpone childbearing because it poses a threat to the further accumulation or preservation of the acquired resources.

Furthermore, workers in jobs with high learning demands may need additional time beyond work to expand their knowledge, follow up on new developments, and attend courses or training sessions. These activities may extend into evenings or weekends, limiting the opportunities for rest, leisure and family time. That may lead to a spillover from paid work to family life (Halbesleben et al., 2009) and further contribute to the postponement or even abandonment of a decision to have a child (*spillover mechanism)*.

Finally, job-related learning demands can influence childbearing decisions through *psychological mechanism*. High learning demands increase mental load and lead to job burnout, as workers are under constant pressure to update information, acquire new work-relevant knowledge, and upgrade their skills (Mauno & Minkkinen, 2020). Since taking care of a child implies a further increase in mental load, resulting from the necessity of navigating the new duties (such as organising care, managing doctor appointments, worrying about child well-being and attending to child's needs), employees working in occupations with high learning demands may find it challenging to accept more mental load and thus may delay or even abandon parenthood.

2.3. Gender Differences in Job Learning Demands and Parenthood Entry

Taken together, job-related learning demands can exert influence on childbearing behaviours, including timing of entry to parenthood, through the mechanisms discussed above. Importantly, these mechanisms operate differently for men and women, differentiating fertility behaviours of women and men in high-learning-demand occupations.

Men usually take shorter parental leaves and are less likely to reduce working hours when they have small children. Even though men's uptake of the parental leave in Germany has increased following the 2007 reform (Geisler & Kreyenfeld, 2019), they take just 10 percent of the total parental leave allowance (Statistisches Bundesamt [Destatis], 2025). Men also rarely reduce their working hours after they become fathers. Women, in turn, typically take longer parental leave (Castro-García & Pazos-Moran, 2016; Reimer, 2020), frequently reduce their working hours after birth (Bianchi, 2000; Ciasullo et al., 2024) and shoulder the majority of childcare responsibilities (Oláh et al., 2018; Steinbach & Schulz, 2022). These gendered patterns imply that in contrast to men, women working in occupations with high learning demands face exceptionally high opportunity costs. Longer time away from work and reduced working hours reduce opportunities for updating and acquiring new skills and contribute to losses of their human capital, both of which are particularly strong in rapidly changing work environment.

These challenges are further amplified by spillover effects. Employees in learning-intensive jobs often need to spend time beyond typical work hours - either in the evenings or over weekends - to stay up-to-date with recent developments in the field or attend training. Yet, mothers are expected to provide childcare, organise playdates or prepare family meals (Barigozzi et al., 2025; Jarosz et al., 2025; Weeks & Ruppanner, 2025) and simply to be

available to children's needs at least in the evening or during the weekends (Hünteler et al., 2024; Samtleben, 2019). In West Germany, in addition, opening hours of childcare institutions are still relatively short and rigid and mothers are expected to pick up their children relatively early, which precludes not only full-time employment of mothers but also participation in learning activities (Zoch, 2024). These responsibilities, shouldered to a larger extent by mothers than fathers, in combination with institutional constraints (childcare opening hours) limit women's ability to invest in the learning that such jobs require, making it increasingly difficult to combine parenthood with occupational responsibilities.

Finally, the mental load associated with combining working in learning-intensive occupations and childrearing may be substantial. Working in learning intensive jobs requires high commitment to work and ability to adapt (Levin, 2015; Naquin & Holton III, 2002). Adding parental responsibilities, especially when they fall disproportionately on mothers, may deplete women's energy reserves which, in turn, may lead them to delay or even forgo motherhood.

Overall, for men in jobs with high learning demands, the costs of having children may be less substantial and a higher income associated with such jobs may lead to increasing the likelihood of fatherhood, in particular later in life when wealth and career gains accumulate. For women, however, the career and personal costs of childbearing are usually greater which may lead to a greater postponement or foregoing childbearing altogether. That could contribute to permanently higher childlessness among women working in learning-intensive occupations.

Importantly, the association between learning demands and childbearing is likely to vary across age groups. Childbearing early during career may hamper career progression and decrease competitive advantage by constraining time and consuming mental resources, particularly for women. However, as experiences accumulate and occupational position solidifies, the risks of childbearing for career progression might become lower. People with established occupational positions might be more willing to stall their careers for the duration of childbearing or parental leave. Some effects, such as the effect of income, may also become more visible later in the career, when resources accumulate. Once individuals' jobs are well established, which takes time, they may choose to accelerate their childbearing plans if they intend to have children (Bratti & Tatsiramos, 2012; Impicciatore & Tomatis, 2020).

3. Data & Method

3.1. Data

This study combines data from two sources. Job-related learning demands are measured at the occupational level based on data from the Occupational Information Network (O*NET). They are linked to individuals' life histories from the National Educational Panel Study (NEPS; see Blossfeld & Roßbach, 2019), Starting Cohort 6 – Adults (NEPS SC6) which contain detailed information on respondents' occupational, educational and family biographies.

O*NET is a comprehensive database that describes occupations in terms of the knowledge, skills, and required abilities as well as how the work is performed in terms of tasks, work activities, tools and technology, etc. In O*NET, occupational characteristics are provided by trained job incumbents and occupational experts based on the Standard Occupational Classification (SOC) system. We used information provided in O*NET to characterize learning demands of occupations. Although the data were collected for American workers, O*NET has been widely applied in studies on the social consequences of European labor market transformations (Adserà et al., 2023; Amuri & Peri, 2014), and has been verified to be suitable for advanced European countries (Lewandowski et al., 2022).

NEPS SC6 is an ongoing longitudinal survey conducted annually, providing data on the educational, employment, and childbearing trajectories of respondents. Retrospective information prior to the first wave of the survey is also available, with precise timing recorded by month and year for each event. Employment histories contain information on respondents' occupations, classified according to the most recent four-digit International Standard Classification of Occupations (ISCO-08). All that allowed us to construct the complete employment and childbearing histories of survey participants. We then linked the O*NET based measures of learning demands to the NEPS respondents' employment histories using information on their occupations. This allowed us to perform a detailed examination of occupational learning demands in relation to individuals' life trajectories.

3.2. Sample

In NEPS SC6, we select individuals born between 1965 and 1984. Skill variety has increased mostly since 1975 (Wood, 2011). Computer technology began spreading across West Germany in the 1980s (Raphael, 2019). Accordingly, individuals who were born in or after

1965 would have entered the labour force around 1985 or later, which means they would be exposed to these processes.

We follow each individual from age 17 until the birth of their first child; or, if no birth occurred, until their last participation in the survey or until they reach age 45. We choose age 17 because it allows us to study the impact of individuals' labour market conditions on births from age 18 onward, accounting for the conception period. We choose age 45 because of female reproductive age limits and apply the same age limits to the male sample to have the identical cohort. The timing of births is determined based on the birth month and year of each individual's first biological child.

Respondents' employment and unemployment history are recorded as episodes, with a start and end year. Combining these episodes with episodes of educational history, we construct a dataset to track individuals' life history annually. Since a change of occupation leads to the creation of a new employment episode, each employment episode has its own unique ISCO-08 four-digit classification. For the episodes in which occupations are not recorded, we impute the occupational classification using the classification from the nearest employment episode of the same individual. As people may have more than one job in a given period, some employment episodes overlap. In such cases, we treat full-time jobs or jobs with longer working hours as the main jobs; if all variables related to working time are unavailable, we select jobs with permanent contracts as the main jobs for that period. Occupations and corresponding learning demands are then coded based on the main jobs.

The initial sample consists of 6,933 female and male respondents. We exclude 24 individuals who do not have any recorded occupation data and 114 individuals who had at least a period of military service, as learning demands are not available for all armed forces occupations. We also exclude 29 individuals who had their first child before age 18, since labour market conditions were not likely to have influence on these births. Seven individuals are automatically dropped in the data cleaning process because they are "inactive" migrants who have no valid episodes of employment, unemployment, or education after age 17. We finally drop four individuals whose place of birth is missing. After applying these criteria, the final sample includes 3,488 women with 2,651 first children (45,098 woman-years) and 3,267 men with 2,051 first children (51,873 man-years).

3.3. Measuring job-related learning demands

We measure job-related learning demands using work activity items related to "updating and using relevant knowledge" in O*NET. This item measures the importance and required level of "keeping up-to-date technically and applying new knowledge to your job". It belongs to the category "occupational requirements" in the O*NET content model, representing descriptors of the work itself, as opposed to descriptors of the worker (Peterson et al., 2001). This category of job characteristics aligns with our theoretical considerations, as job-related learning demands reflect the requirements imposed on employees, which differs by the specificity of their occupations.

In O*NET learning demands of occupations are assessed for each occupation classified at the 6-digit level of the Standard Occupational Classification (SOC) on a scale from 0-7, where a score of zero indicates that the occupation does not require workers to learn, and higher scores indicate that workers are frequently expected to acquire and apply new knowledge and skills. The assessment is made since 1998 but it went through several changes in how the evaluations were made. At the beginning they were made by occupational analysts based on its predecessor Dictionary of Occupational Titles (DOT). The transitional period from DOT to O*NET lasted until 2002. Between 2003 and 2007, the data collection method has been gradually changed to a multi-method featuring job incumbent, occupational expert, big data, and other sources. Since O*NET updates only a subset of occupations each year rather than the full dataset, assessments during this period exhibit substantial variation due to differences in data collection methods across occupations. To ensure consistency and comparability, we use occupational data from 2008 onward, that is when the new data collection system was fully implemented. Additionally, the COVID-19 pandemic dramatically altered workplaces and work practices (Kniffin et al., 2021), causing post-pandemic updates to deviate from historical trends. We therefore calculate the average learning-demand rating for each occupation over 2008–2019, using it as a proxy for the typical level of learning demands in the long run. This approach captures persistent occupational characteristics and excludes disturbances caused by the changes in data collection techniques or by the pandemic. In our dataset, all occupations demonstrate a level of learning demands, ranging from 1.3 to 6.1.

In the next step, we use crosswalks between the Standard Occupational Classification (SOC) system[1] and the International Standard Classification of Occupations version 2008 (ISCO-08) developed by Hardy et al (2018) to create a dataset in which all occupations are classified according to the four-digit ISCO-08 system. The level of learning demands remains highly stable over time for most occupations in this system, with 405 out of 422 occupations exhibiting a standard deviation below 0.5. We then categorise learning demands into quartiles to account for potential non-linear effects as influence of learning demands on individuals is unlikely to increase in a linear fashion but rather by thresholds. By dividing the learning demands into quartiles, we are better able to capture these potential threshold effects and allow for a more flexible modelling of the relationship. An additional reason to use quartiles is because they allow using an additional code (zero) for a situation when an individual is not working.

Some occupations may be overrepresented in the sample leading to biased estimates, to correct for that, each occupation is weighted by how many people held it, and learning demand quartiles are assigned based on this population-weighted distribution (Solon et al., 2015).

3.4. Method

We employ discrete-time complementary log-log (cloglog) models with cluster standard errors, estimated separately for male and female samples. The cloglog model estimates the log of the hazard rate as a linear function of covariates, linking the probability of first birth in a given year to both individual characteristics and temporal context. This specification captures the effects of both time-to-event and covariates and provides a close approximation to the continuous-time hazard function (Buckley & Westerland, 2004). We model the time to parenthood using annual data to balance computational efficiency with estimation precision. The discrete-time approach is also less restrictive regarding the exact timing of events, making it well suited to survey data where some events lack precise timing information. Finally, we cluster standard errors at the individual level to account for within-person correlation over time.

Our process time is age grouped as 17–19, 20–24, 25–29, 30–34, 35–39, and 40–45. In a complementary log-log model, the effect of covariates is assumed to be proportional to the baseline hazard within each time interval—that is, covariates shift the baseline hazard by

[1] Different versions of SOC codes were used in the ONET datasets across years. To ensure consistency, we first used the crosswalks provided on the O*NET website (https://www.onetcenter.org/taxonomy.html) to create a dataset in which all occupations are classified according to the SOC 2010 system.

a constant factor across ages. However, the influence of learning demands may not be proportional over the life course, as individuals in occupations with high learning demands are expected to postpone childbearing to later ages. To account for this potential time-varying relationship, we interact learning demands with the age-group indicators representing process time. This is important because individuals facing high learning demands typically have higher education, enter the labor market later, and may postpone family formation to establish themselves professionally. By interacting learning demands with process time, we can assess whether high learning demands are associated with a postponement of births at different ages, rather than assuming a uniform effect.

We include a range of control variables in our models. First, we control for major occupational groups using the one-digit ISCO-08 classification to account for general occupational characteristics that may influence both learning demands and the timing of first birth. We include a control for employment sector (public vs. private) because public sector employees often enjoy more stable employment and more supportive family policies, they may respond differently to learning demands and also tend to have their first child earlier. We also control for working schedules to capture differences in childbearing behaviour and learning demands between full-time and part-time jobs. Since individuals with different labor market or educational status may exhibit distinct fertility behaviours, we classify their status into four categories: in education, inactive, unemployed, and employed. To capture period effects, we include time-period controls: before 1990, 1991–2003, 2004–2007, 2008–2012, 2013–2019, and 2020–2022. We also include educational attainment (coded as "high" for individuals with at least a bachelor's degree or equivalent, and "low/middle" for all others), and place of birth (West Germany/West Berlin, East Germany/East Berlin, or outside Germany). Finally, we control for an individual's income as proxy of their socioeconomic status which may affect both their choice of occupation and childbearing.

As questions about income are sensitive, the nonresponse rate is generally higher than for other survey items (Riphahn & Serfling, 2005). In NEPS, approximately 10 percent of net income is not reported by the respondents (Aßmann et al., 2017). In contrast to other life-course variables that are collected retrospectively in the NEPS, income is reported only for the current period at the time of the interview. Consequently, income information for years before 2007 is almost entirely missing. To address these challenges, we apply a two-step approach to impute income data. First, for data from 2007 onwards, we used the MICE (Multiple Imputation by Chained Equations) method with CART (Classification and Regression Trees) to impute

missing income values. This approach is suggested and validated by Aßmann et al (2017). We then recode income into income groups, defined as low (≤25th percentile), middle (26th–75th percentile), and high (>75th percentile). Based on this imputed dataset, a CatBoost (Categorical Boosting) model was trained to predict income group classifications. CatBoost is well suited for this task because it handles categorical variables efficiently without requiring extensive preprocessing, and it often outperforms other gradient boosting algorithms on datasets with mixed data types (Hancock & Khoshgoftaar, 2020). We then applied the trained CatBoost model to infer income group data for observations prior to 2007, ensuring consistency in the income variable across the full-time range. All control variables are lagged by one year to account for the timing of conception.

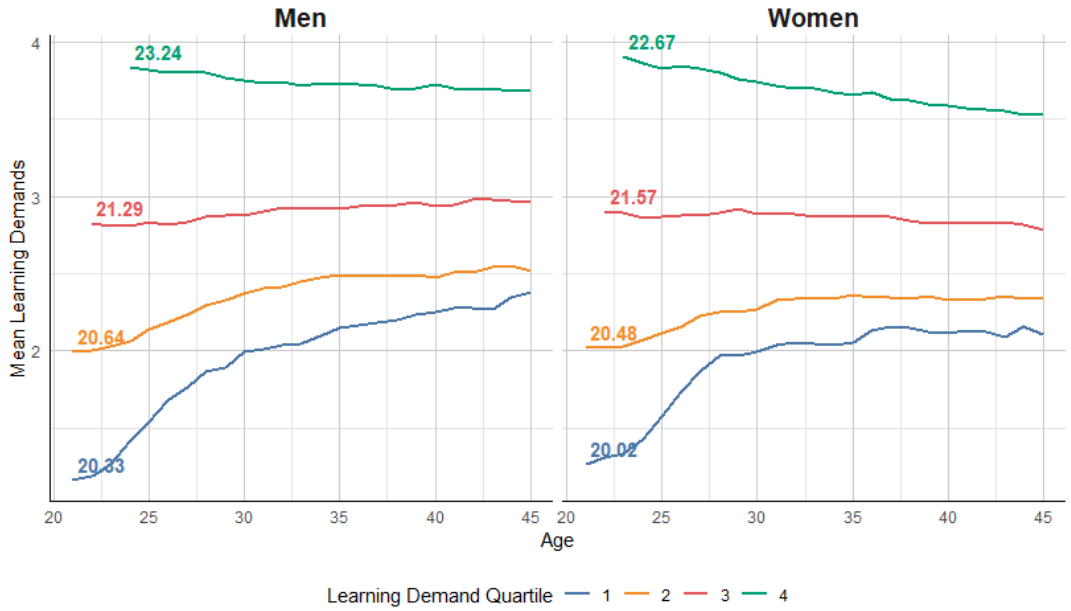
4. Results

4.1. Descriptive statistics

Figure A1 (supplementary materials) shows the characteristics of individuals employed in occupations with varying levels of learning demands (more detailed descriptive statistics are presented in Table A1 in the supplementary materials). All distributions are calculated based on employment spells (person-year observations), as individuals could have multiple jobs over the observation period. As the level of learning demands increases, the share of highly educated individuals rises, primarily because occupations with intensive learning demands typically require higher skills at entry. Figure A2 provides complementary perspectives to the overall patterns shown in Figure A1, indicating that jobs with above-median learning demands have similar shares for men and women in total employment spells, while in lower-demand occupations, women are more likely to work in the second quartile, and men dominate the lowest quartile.

Next, we demonstrate that the employment trajectories regarding the occupational learning demands are highly correlated with individuals' jobs shortly after graduation from formal education. For simplicity, we define each individual's "first job" as the earliest employment spell that begins at or after the age at which they have completed formal education. As shown in Figure 1, individuals who start in higher learning-demand jobs enter the labour market, on average, around three years later due to longer education. For both men and women, the learning demands of the first job strongly predict the levels of learning demands in their subsequent jobs. Gaps in job-related learning demands between groups persist for both sexes until age 45.

Figure 1. Mean learning demands over age, by sex and first job learning demand quartile, Germany, 1965–1985 cohorts



Source: Authors' analysis of data from O*NET and NEPS SC6.

Note: the trajectories are calculated based on the mean level of learning demands for each group by age.

4.2. Learning demands and first birth timing

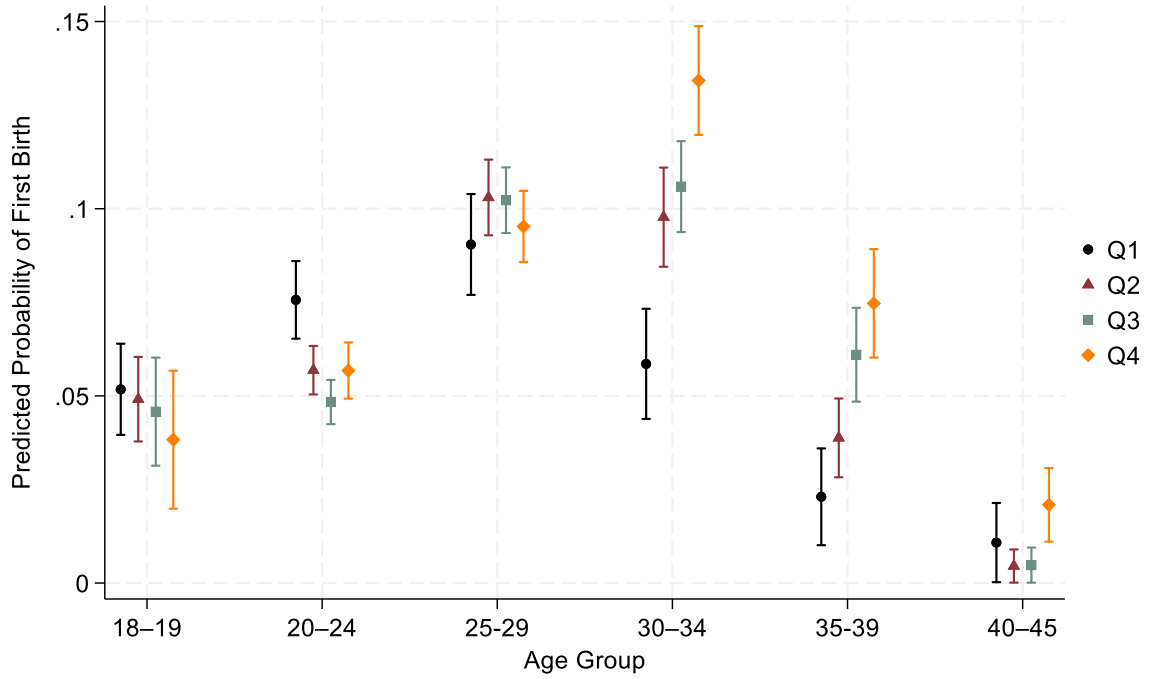
In Table A2 in the supplementary materials, we present the regression results for the female (Model 1) and male samples (Model 2). For simplicity, we base our interpretations on predicted first birth conditional probabilities for different levels of learning demands in Figure 2A and 2B. In order to evaluate whether the difference between two predicted probabilities is significant at 0.05 we follow Austin & Hux (2002) and use 83% confidence intervals, as non-overlapping 83% CIs more closely approximate a p-value of 0.05.

Our results suggest that for both men and women, having jobs with higher levels of learning demands is associated with a postponement of childbearing. Women with the lowest level of learning demands predominantly become mothers in their 20s. Between ages 20 and 24, these women have a significantly higher probability of transitioning to motherhood than any other group. After the age of 30, the likelihood of entering motherhood drops sharply for women in jobs with low learning demands. Women subject to moderate learning demands (2nd and 3rd quartile) are, in turn, most likely to become mothers when they are 25-29 or 30-34. Women with highest learning demands postpone motherhood most significantly: they are most likely to have their first child between the ages 30 and 34. Furthermore, conditional probability of becoming mothers for this group of women is the highest after the age of 30. After age 40,

this group is the only one whose predicted probability of first birth remains significantly above zero.

Men in the lowest quartile of learning demands also tend to become fathers earlier. Their probability of transitioning to fatherhood is the highest for the ages of 20-24 and 25-29. In turn, men with high learning demands (3rd and 4th quartile) are most likely to become fathers after 30.

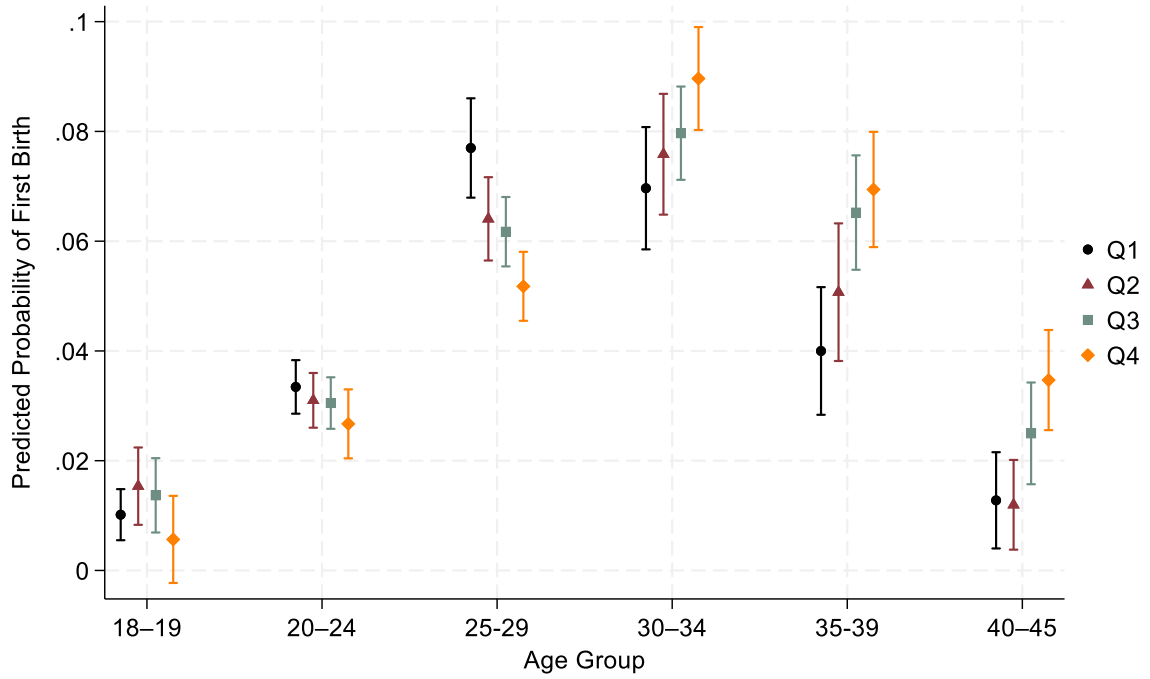
Figure 2A. Predicted probability of first birth among women by learning-demand quartile, Germany, 1965–1985 cohorts



Source: Authors' analysis of data from O*NET and NEPS SC6.

Note: Predicted probabilities and 83 per cent CIs are calculated based on the estimates from Model 1, controlling for birth place, educational level, age group, income group, working/education status, major occupation group, period, full-/part-time schedule and private/public sector.

Figure 2B. Predicted probability of first birth among men by learning-demand quartile, Germany, 1965–1985 cohorts



Source: Authors' analysis of data from O*NET and NEPS SC6.
Note: Predicted probabilities and 83 per cent CIs are calculated based on the estimates from Model 2, controlling for birth place, educational level, age group, income group, working/education status, major occupation group, period, full-/part-time schedule and private/public sector.

4.3. Learning demands and childlessness /ultimate entry to parenthood by age 45

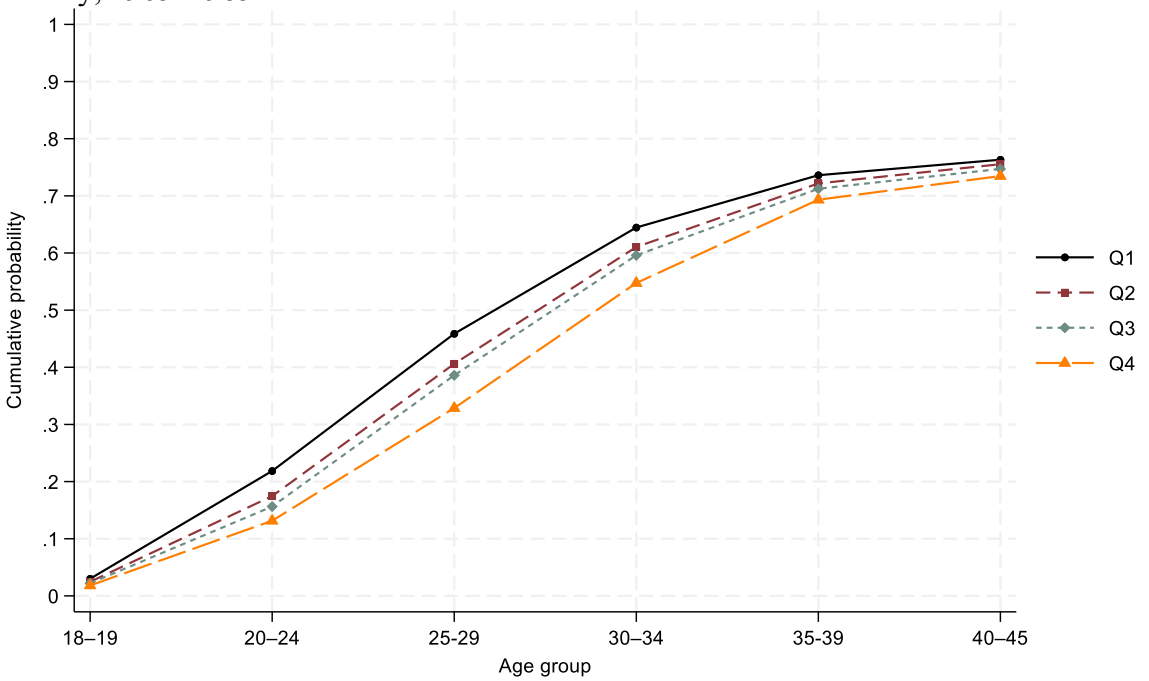
To examine whether the probability of becoming the parent by age 45 also depends on learning demands, we calculate cumulative incidence curves showing the final share of individuals who become parents by age 45. These curves, defined as 1 minus the survivor function, are derived from the predicted hazards in Model 1 and Model 2. The calculation requires selecting specific covariate constellations. As before, we compute the curves by gender and by the learning demands of individuals' first jobs. As shown in Figure 1, the learning demands of a person's first job after graduation predict distinct employment trajectories in terms of learning demands.

The cumulative incidence curves are shown in Figure 3A (women) and 3B (men). Women and men who start in occupations with higher learning demands postpone parenthood more strongly than those start in jobs with low learning demands, consistently with what we showed in the previous section. For instance, by age 25-29, 46% of women starting in occupations with lowest learning demands (1st quartile) are already mothers while among women starting in the most demanding occupations this proportion is only 33%. The difference between the two groups narrows over time, however, as women starting in the highest learning demands job

recuperate childbearing. From their 30s onward, the cumulative probabilities converge across groups. By age 40-45, which is close to the end of the reproductive period, childlessness rates range from 23.7% for women starting in the lowest learning demand jobs to 26.5% for women starting in the most demanding jobs.

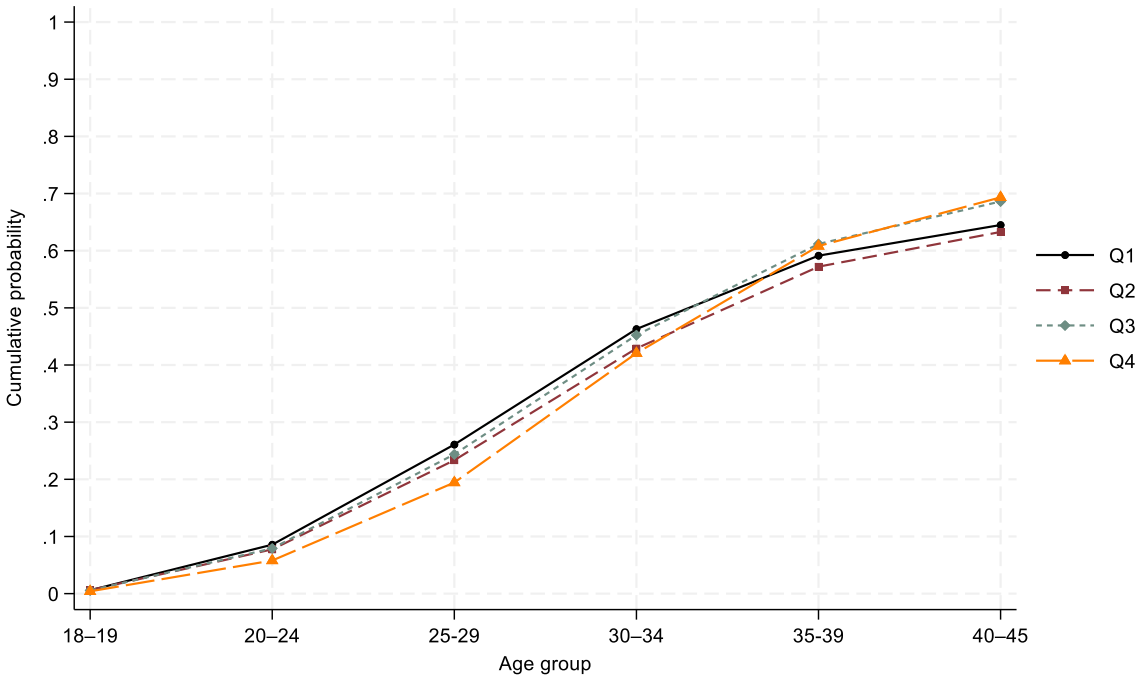
As for men, we also observe postponement of entry to parenthood among those with the highest learning demands. However, the difference between men facing the lowest and highest learning demands is smaller than among women. For example, by age 25–29, nearly 26% of men starting in occupations with the lowest learning demands (1st quartile) are already fathers, compared to only 19% among men starting in the most demanding occupations. From age 35 onward, the cumulative incidence curves for men starting in the highest learning demands cross those for men starting in lower learning demands (1st and 2nd quartiles). As a result, men starting in highly demanding occupations eventually become less likely to remain childless than men starting in the less demanding occupations. By age 45, 31% of men with above-median learning demands early in their careers remain childless, compared to approximately 36% of men with lower learning demands. Given the observed trend and the fact that only about 6% of men in Germany have children after age 45 (Dudel & Klüsener, 2016), this gap is unlikely to be fully closed. These findings therefore suggest that men in jobs with lower learning demands early in their careers are more likely to remain childless.

Figure 3A. Cumulative probability of first birth among women by learning-demand quartile, Germany, 1965–1985 cohorts



Source: Authors' analysis of data from O*NET and NEPS SC6.
Note: For model results, see Figure 2A. Person-years = 45,098.

Figure 3B. Cumulative probability of first birth among men by learning-demand quartile, Germany, 1965–1985 cohorts



Source: Authors' analysis of data from O*NET and NEPS SC6.
Note: For model results, see Figure 2B. Person-years = 51,873.

4.4. Robustness check

We conduct two robustness checks. First, as an alternative to estimating models using 4-digit ISCO codes, we estimate the models using the 3-digit occupational classification, where learning demands are assigned by averaging the values of all 4-digit occupations within each 3-digit group and re-ranking the quartiles accordingly. This approach captures job characteristics at a more aggregate level, helping to reduce potential measurement error arising from cross-national differences in overly detailed occupational coding and to smooth out idiosyncratic noise. The results are presented in Figures A 3.1 and A 3.2. The results are not significantly different from our main specifications.

Next, to assess the robustness of our results to the imputation of income data, we extract multiple completed datasets from the MICE procedure with CART, corresponding to the different imputed draws. Then, we vary the random seed used in the imputation process. By re-estimating our models across these different imputed datasets and seeds, we verify that the main results remain consistent, indicating that our findings are not driven by a particular imputed dataset or the stochastic elements of the imputation procedure. We present the results in Figure A 4.1 and A 4.2.

6. Discussion

The rapid pace of technological innovation, together with major shifts in the global economy and society, has increased the demand for continuous learning, making it a critical factor for individuals in the evolving labour market (World Economic Forum, 2025). While rising learning demands are shaping work life, their potential demographic consequences remain understudied. To fill in this gap, this study examines how job-related learning demands relate to the transition to parenthood. We focus on men and women living in Germany and born between 1965 and 1984.

Our results show that individuals in jobs with high learning demands tend to postpone childbearing. Consistently with our expectations, the effect of learning demands on postponement is stronger among women than men. However, this delay does not necessarily reduce their overall likelihood of becoming parents. Women in learning-intensive jobs are only slightly less likely to become mothers by the end of their reproductive years than those in jobs which require little learning, whereas men in similar jobs are even slightly more likely to become fathers by age 45.

Several mechanisms explain these findings. We were able to exclude the income mechanism as the effects we observe are estimated net of income. This implies that the higher probability of fatherhood among men in learning-intensive occupations cannot be attributed solely to earnings. It is likely that jobs with high learning demands also offer other advantages—such as stronger employment security, long-term career prospects or better job satisfaction—which we did not account for in our study and that make men attractive partners with high chances of becoming fathers.

In case of women, however, these benefits seem to constitute opportunity costs of childbearing. Despite an increase in men's involvement in childcare and housework women still shoulder higher proportion of domestic obligations, in particular after a child is born (Baxter et al., 2008; Doan & Quadlin, 2019; Nitsche & Grunow, 2016). This is also the case in Germany where women take much larger proportion of the parental leave and often reduce working hours after they become mothers (Boeckmann et al., 2015; Schober, 2014). There is also broad evidence that mothers shift into less challenging jobs after birth (Laurijssen & Glorieux, 2013) and that they are less likely to participate in training compared to childless women or (Stoilova et al., 2023; Zoch, 2024), likely because the demands of unpaid care work spill over into paid employment, making it difficult to sustain intense learning and demanding position at work. These findings imply that mothers not only lose the human capital during

the career breaks but most importantly face difficulties with rebuilding it and catching up with work-related changes and demands, losing access to work-related benefits (high position, career prospects) that they had invested in building though working in demanding jobs before motherhood. Aware of these possible loses they postpone entry to motherhood until late reproductive ages.

Importantly, however, this postponement does not necessarily preclude motherhood. Our findings show that many women in occupations with high learning demands eventually become mothers, and by their mid-40s, the incidence of childlessness in this group of women approaches that among women in jobs with low learning demands. We cannot determine from our data whether the decision to enter motherhood is caused by the fact that learning demands ease later in the career—due to accumulated knowledge or access to team-based support—or whether women develop effective coping strategies or they reach the stage in their reproductive careers in which they feel this is the last moment for becoming mothers. In any case, the fact that most women eventually make this transition is an encouraging finding. Still, the implications of this postponement may be significant. First, delayed entry into parenthood reduces the time left for having additional children and potentially contributes to lower cohort fertility. Second, given the biological decline in fecundity after age 35 (Steiner & Jukic, 2016), some women who postpone fertility may not be able to become pregnant at older ages which may in turn increase involuntary childlessness.

The consequences of these patterns are likely to become even more pronounced as technological progress continues. The development of AI is projected to increase the demand for high and adaptable skills, such as complex problem-solving, creativity, and social interaction, which intensifies the need for continuous learning (Green, 2024; Mäkelä & Stephany, 2024). As a result, workers who can reskill quickly and integrate new technologies into their work, will be more likely to maintain their jobs and earn good wages in contrast to those who are less capable to adjust to the ongoing changes (Babina et al., 2023). These developments may raise the opportunity costs of career interruptions or reduced working hours, since knowledge and digital skills may depreciate faster in rapidly evolving environments. In such a context, more workers—particularly women in high-learning-demand jobs—may be inclined to delay family formation in order to consolidate their career. Yet this postponement can come at the cost of reduced completed fertility when even having one child may appear impossible.

This study comes with important limitations. First, we cannot account for the individual and job characteristics of respondents' partners. This is due to substantial missing data on the timing of partnership dissolution in the NEPS SC6, which prevents us from constructing a reliable and comprehensive partnership history. Partners' characteristics such as educational attainment, age, income, working hours, and access to family-friendly workplace policies can also influence individuals' childbearing decisions (Kaufman & Bernhardt, 2012; Trimarchi & Van Bavel, 2020). Second, we use a time-invariant measure of occupation-level learning demands and therefore do not account for any absolute intensification within occupations over time. This is partially because, in O*NET, learning demands are measured on a 0–7 relative scale rather than in absolute terms. Consequently, the occupational values are highly stable over time — between 2008 and 2019, the year-to-year correlations range from 0.979 to 0.992 across the occupations. Given this stability, using the quartile of the mean level over this period is a reasonable operationalization. However, this approach limits our analysis to between-occupation variation only. Third, the quality of income data is somewhat limited, as around three quarters of births are modelled based on imputed values. While we conduct robustness checks to support the validity of the results, more complete income data would further improve the estimates and help clarify the underlying mechanisms.

Despite these limitations this study makes an important contribution to the literature by paying attention to growing learning demands as another consequence of labour market transformations driven by globalisation and technological change which may have important repercussions for family formation. To date research in family demography has largely concentrated on discussing the implications of destandardisation of employment careers. With this study we have identified another important dimension of the labour market change which may in parallel affect childbearing. In fact, our study demonstrates that even in stable, often well-remunerated occupations, high learning demands can delay the transition to parenthood. This highlights the importance of moving beyond job security when considering how labour market transformations influence family formation.

Future research should aim to look more closely into the mechanisms underlying the observed associations, to better understand what precisely constraints fertility decisions. Further work should also extend the analysis to higher-order births, as postponement of first births may have compounding effects on completed fertility. Next, accounting for partner characteristics would allow for understanding how couples make fertility decisions when both

partners are in highly demanding jobs. Finally, comparative research is needed to examine whether these associations vary across gender and welfare state regimes.

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Supplementary materials

Table A1. Summary Statistics – categorical covariates

Variable	levels	Female		Male	
		Frequency	Percent	Frequency	Percent
Quantile of learning demands	Not employed	14,848	32.9	16,465	31.7
	1st	4,366	9.7	7,879	15.2
	2nd	9,290	20.6	8,035	15.5
	3rd	8,276	18.4	9,643	18.6
	4th	8,318	18.4	9,851	19
Birth place	West Germany/West Berlin	33,668	74.7	37,912	73.1
	East Germany/East Berlin	6,935	15.4	9,052	17.5
	Outside Germany	4,495	10	4,909	9.5
Educational level	Medium or low	21,874	48.5	25,132	48.4
	High	23,224	51.5	26,741	51.6
Age group	18-19	10,278	22.8	9,780	18.9
	20-24	14,814	32.8	15,446	29.8
	25-29	10,317	22.9	12,487	24.1
	30-34	5,313	11.8	7,727	14.9
	35-39	2,775	6.2	4,211	8.1
	40-45	1,601	3.6	2,222	4.3
Income group	Not employed	14,849	32.9	16,437	31.7
	Low	4,501	10	3,336	6.4
	Medium	23,029	51.1	24,383	47
	High	2,719	6	7,717	14.9
Working/education status	In education	21,921	48.6	24,330	46.9
	Inactive	175	0.4	146	0.3
	Unemployed	1,083	2.4	2,102	4.1
	Employed	21,919	48.6	25,295	48.8
Major occupation group	Managers	625	1.4	1,286	2.5
	Professionals	6,074	13.5	7,659	14.8
	Technicians and associate professionals	8,665	19.2	5,309	10.2
	Clerical Support Workers	6,625	14.7	3,083	5.9
	Service and Sales Workers	4,973	11	2,805	5.4
	Skilled Agricultural, Forestry and Fishery Workers	168	0.4	862	1.7
	Craft and Related Trades Workers	1,203	2.7	9,847	19
	Plant and Machine Operators, and Assemblers	475	1.1	2,074	4
	Elementary Occupations	1,442	3.2	2,483	4.8
	Not employed	14,848	32.9	16,465	31.7
Period	before 1990	10,199	22.6	9,874	19

Variable	levels	Female		Male	
		Frequency	Percent	Frequency	Percent
	1991-2003	23,628	52.4	26,512	51.1
	2004-2007	5,598	12.4	7,346	14.2
	2008-2012	4,098	9.1	5,823	11.2
	2013-2019	1,508	3.3	2,218	4.3
	2020-2022	67	0.1	100	0.2
Full-/part-time schedule	Part-time	7,773	17.2	3,987	7.7
	Full-time	22,477	49.8	31,421	60.6
	Not employed	14,848	32.9	16,465	31.7
Sector	Public sector	8,575	19	6,174	11.9
	Private sector	21,675	48.1	29,234	56.4
	Not employed	14,848	32.9	16,465	31.7
Total		45098	100	51873	100

Source: Authors' calculations based on NEPS data

Table A2. Baseline regression results

Predictors	Female samples	Male samples
Quartile of learning demands (*ref. 1st quartile*)		
Not employed	1.246	0.056***
	(0.702)	(0.046)
2nd quartile	0.947	1.517
	(0.223)	(0.710)
3rd quartile	0.881	1.351
	(0.259)	(0.658)
4th quartile	0.733	0.555
	(0.294)	(0.600)
Age group (*ref. 17-19*)		
20-24	1.484*	3.338***
	(0.275)	(1.161)
25-29	1.793**	7.891***
	(0.347)	(2.727)
30-34	1.136	7.108***
	(0.283)	(2.536)
35-39	0.437	4.008***
	(0.194)	(1.602)
40-45	0.203*	1.260
	(0.150)	(0.763)
Learning demands and group (ref. 1st quartile and age 17 to 19)		
Not employed and age 20 to 24	0.930	1.062
	(0.207)	(0.440)

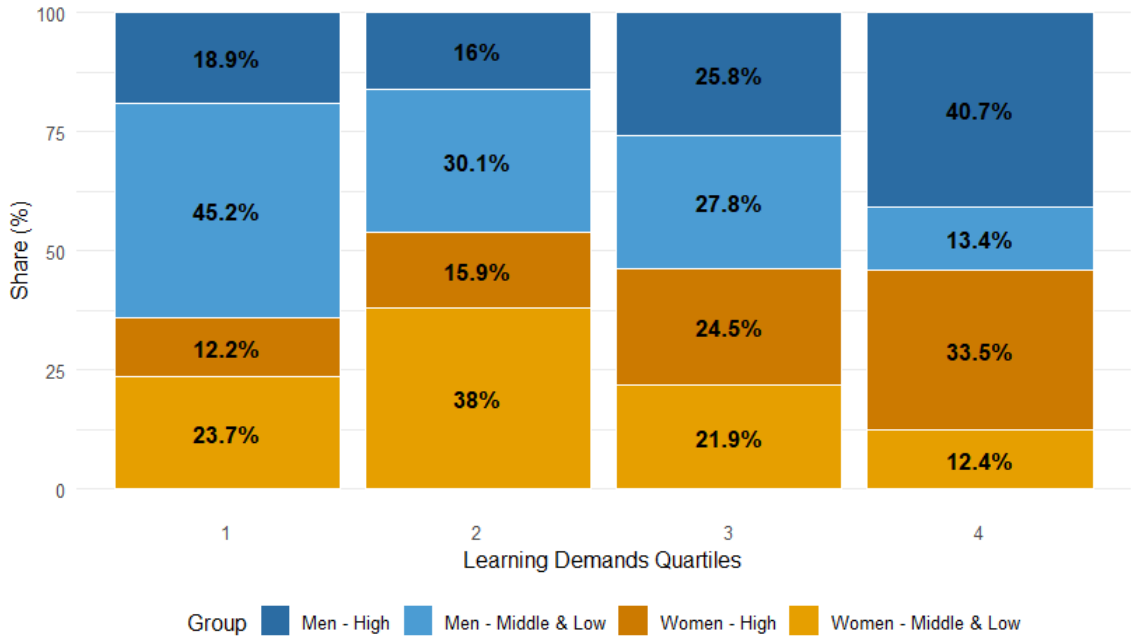
Predictors	Female samples	Male samples
Not employed and age 25 to 29	1.208	0.940
	(0.309)	(0.393)
Not employed and age 30 to 34	1.213	1.448
	(0.484)	(0.689)
Not employed and age 35 to 39	1.726	1.224
	(1.086)	(0.813)
Not employed and age 40 to 45	1.677	-
	(2.167)	-
2nd quartile and age 20 to 24	0.784	0.610
	(0.200)	(0.300)
2nd quartile and age 25 to 29	1.212	0.544
	(0.312)	(0.262)
2nd quartile and age 30 to 34	1.808	0.721
	(0.557)	(0.355)
2nd quartile and age 35 to 39	1.794	0.841
	(0.911)	(0.458)
2nd quartile and age 40 to 45	0.441	0.617
	(0.457)	(0.524)
3rd quartile age 20 to 24	0.712	0.674
	(0.220)	(0.343)
3rd quartile age 25 to 29	1.293	0.588
	(0.396)	(0.294)
3rd quartile age 30 to 34	2.118*	0.852
	(0.734)	(0.432)
3rd quartile age 35 to 39	3.076*	1.226
	(1.599)	(0.666)
3rd quartile age 40 to 45	0.500	1.458
	(0.525)	(1.092)
4th quartile age 20 to 24	1.011	1.433
	(0.413)	(1.571)
4th quartile age 25 to 29	1.440	1.193
	(0.586)	(1.294)
4th quartile age 30 to 34	3.290**	2.348
	(1.433)	(2.549)
4th quartile age 35 to 39	4.570**	3.184
	(2.657)	(3.511)
4th quartile age 40 to 45	2.652	4.957
	(2.345)	(5.960)
Major occupation groups (*ref. managers*)		

Predictors	Female samples	Male samples
Professionals	0.896	0.940
	(0.144)	(0.122)
Technicians and associate professionals	0.948	1.032
	(0.149)	(0.131)
Clerical support workers	0.811	0.752
	(0.140)	(0.116)
Service and sales workers	0.875	0.814
	(0.155)	(0.127)
Skilled agricultural, forestry and fishery workers	1.167	0.943
	(0.347)	(0.183)
Craft and related trades workers	0.859	0.917
	(0.169)	(0.118)
Plant and machine operators, and assemblers	1.096	0.847
	(0.239)	(0.135)
Elementary occupations	0.765	0.928
	(0.158)	(0.152)
Income group *(ref.low)*		
Not employed	0.213***	10.620**
	(0.108)	(7.686)
Middle	0.950	1.105
	(0.056)	(0.120)
High	0.813*	1.793***
	(0.085)	(0.209)
Sector *(ref. public)*		
Private sector	0.849***	1.097
	(0.042)	(0.072)
Working schedule (*ref. part-time)*		
Full-time	0.627***	1.417**
	(0.031)	(0.152)
Working/education status (*ref. employed*)		
In education	0.453***	0.797***
	(0.029)	(0.053)
Inactive	1.926	0.938
	(0.676)	(0.606)
unemployed	1.927***	1.387
	(0.307)	(0.261)
Educational level (*ref. low/middle*)		
High	0.773***	0.914
	(0.036)	(0.048)

Predictors	Female samples	Male samples
Birth place (*ref. West Germany/West Berlin*)		
East Germany/East Berlin	1.740***	1.396***
	(0.097)	(0.084)
Outside Germany	1.673***	1.953***
	-0.108	(0.143)
Period (*ref. before 1990*)		
1991-2003	0.804***	0.841
	(0.053)	(0.080)
2004-2007	0.705***	0.685***
	(0.061)	(0.075)
2008-2012	0.722***	0.669***
	(0.069)	(0.078)
2013-2019	0.755*	0.773
	(0.103)	(0.105)
2020-2022	0.289	0.157
	(0.289)	(0.157)
Constant	0.142***	0.007**
	(0.036)	(0.003)
Observations	45,098	57,873
Number of individuals	3,488	3,267

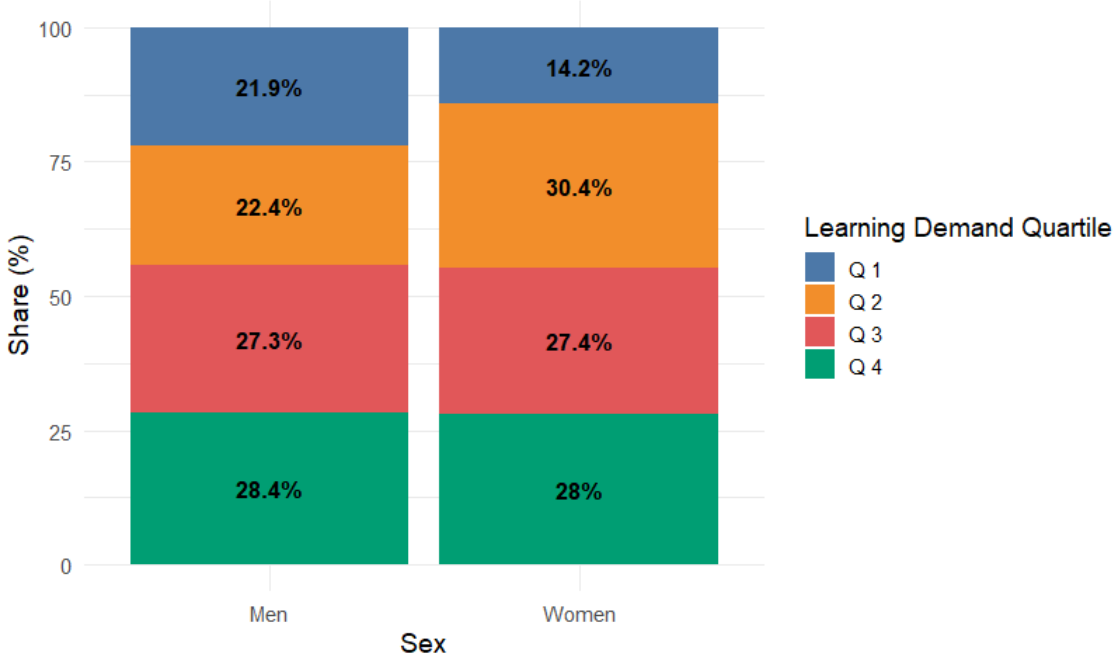
Source: Authors' analysis of data from O*NET and NEPS SC6.

Figure A1. Composition of education & sex by learning demands quartile, shares based on spell count, Germany, 1965–1985 cohorts



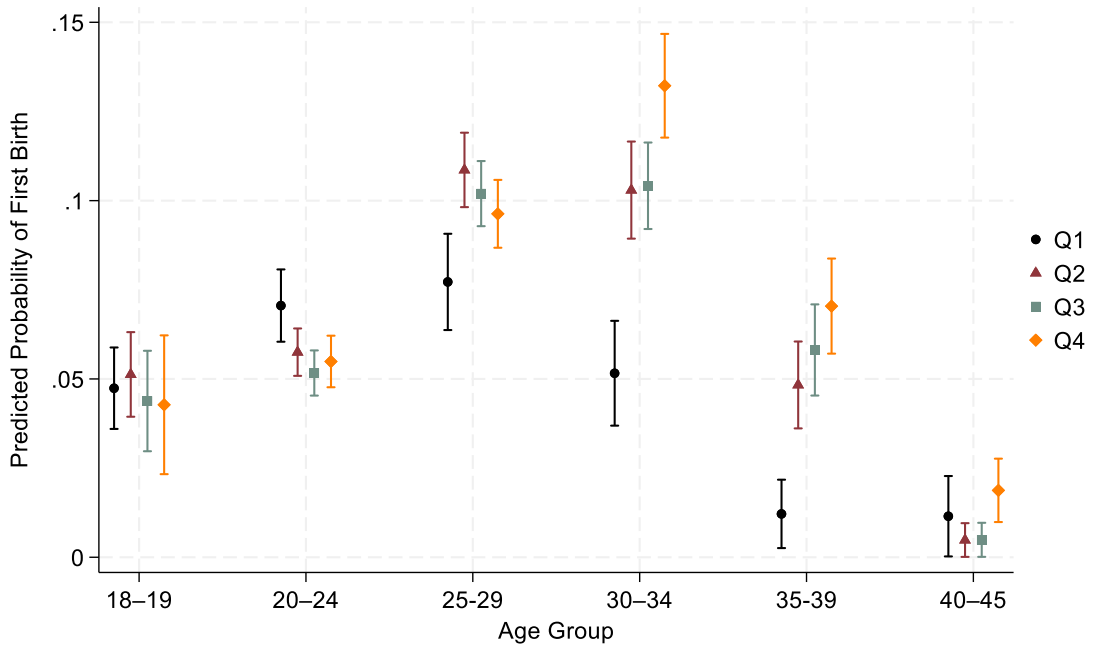
Source: Authors' analysis of data from O*NET and NEPS SC6.

Figure A2. Composition of learning demands by sex, shares based on spell count, Germany, 1965–1985 cohorts



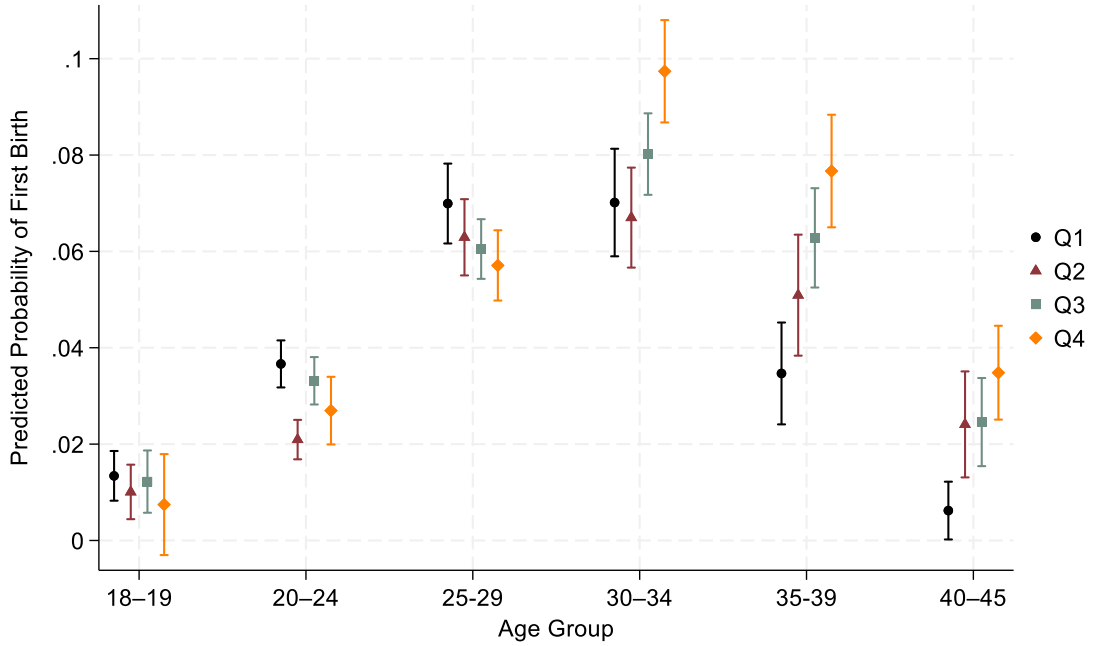
Source: Authors' analysis of data from O*NET and NEPS SC6.

Figure A 3.1. Predicted probability of first birth among women by learning-demand quartile of 3-digit occupational classification, Germany, 1965–1985 cohorts



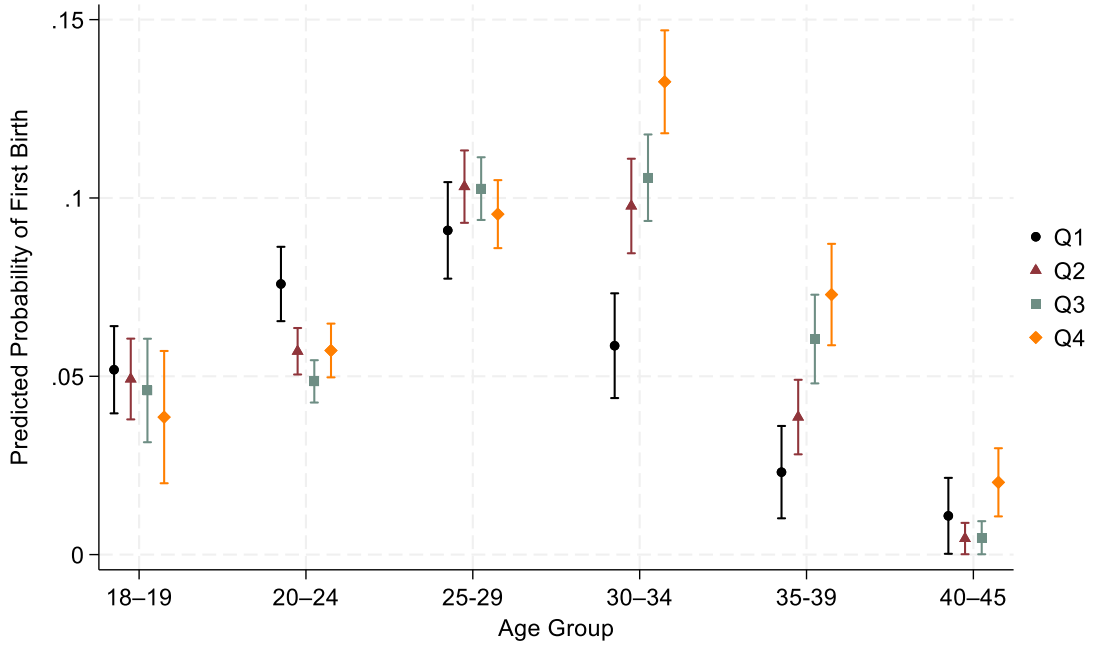
Source: Authors' analysis of data from O*NET and NEPS SC6.

Figure A 3.2. Predicted probability of first birth among men by learning-demand quartile of 3-digit occupational classification, Germany, 1965–1985 cohorts



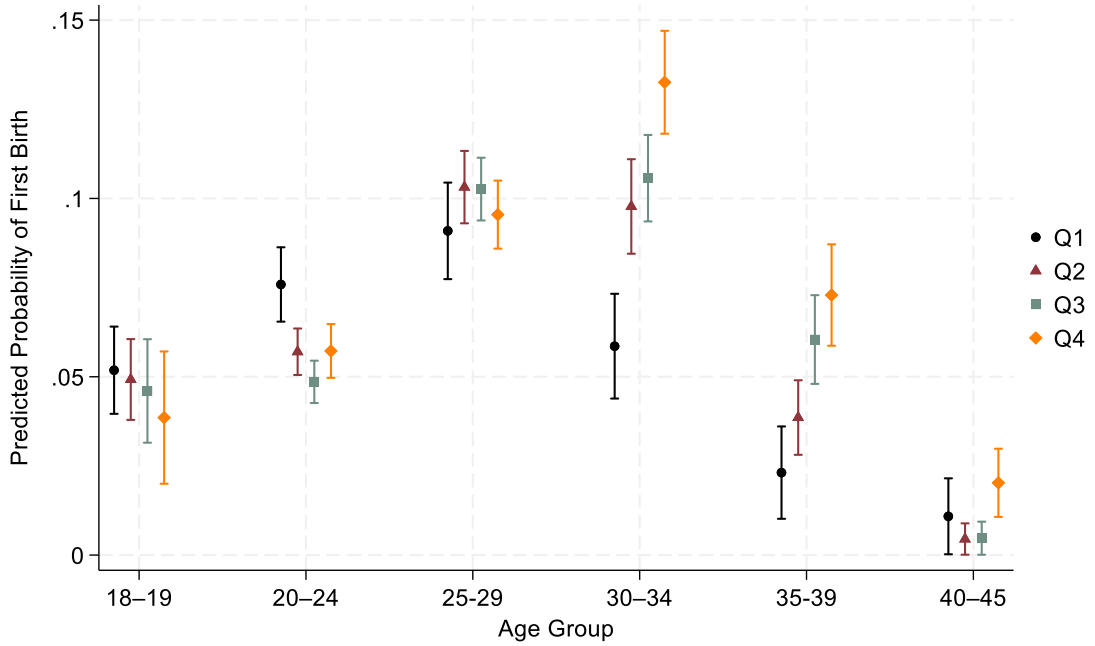
Source: Authors' analysis of data from O*NET and NEPS SC6.

Figure A 4.1. Predicted probability of first birth among women by learning-demand quartile using different income imputation methods, Germany, 1965–1985 cohorts



Source: Authors' analysis of data from O*NET and NEPS SC6.

Figure A 4.2. Predicted probability of first birth among men by learning-demand quartile using different income imputation methods, Germany, 1965–1985 cohorts



Source: Authors' analysis of data from O*NET and NEPS SC6.

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